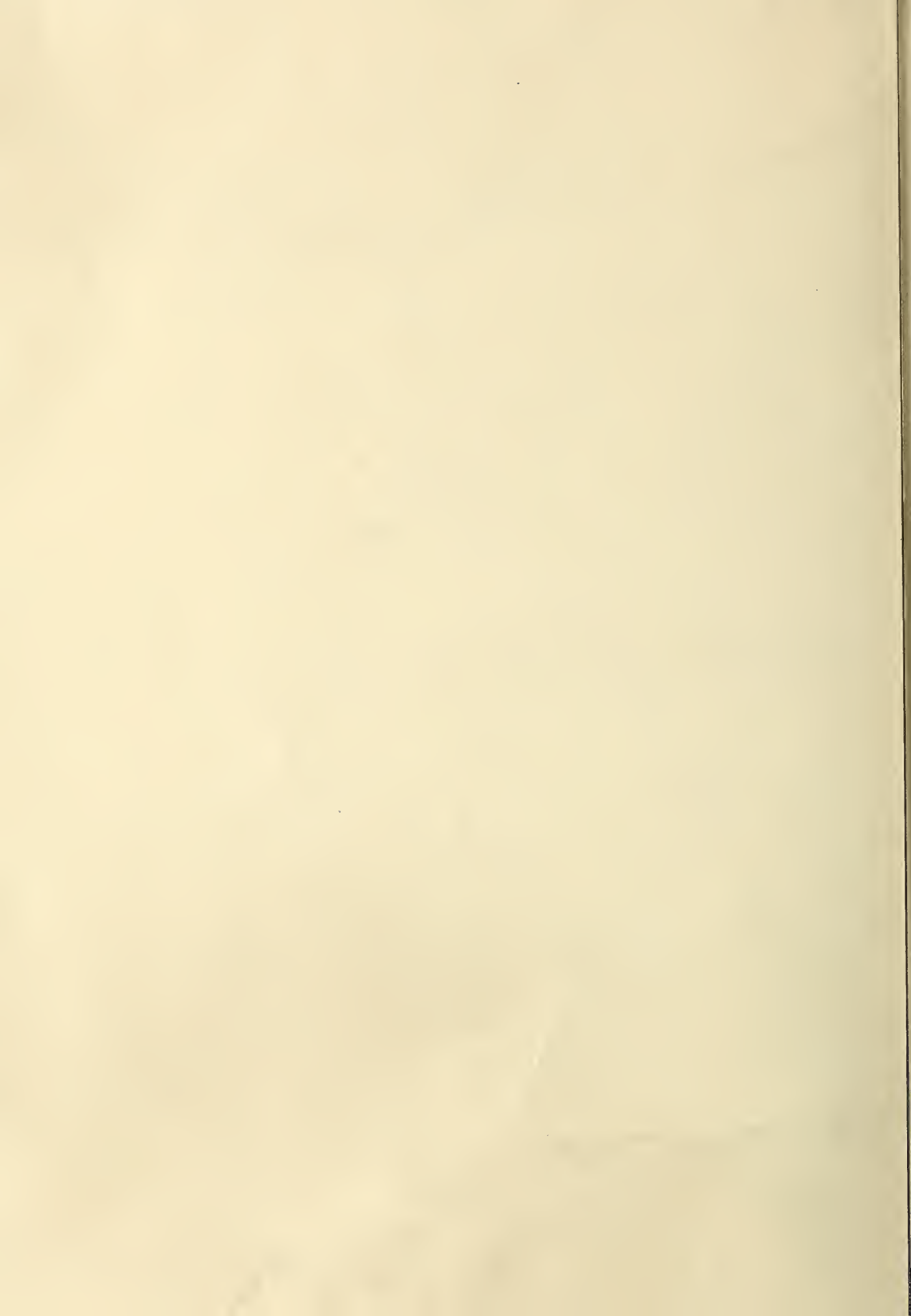


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FINAL REPORT

EFFECTS OF FREEZING RATE, STORAGE TEMPERATURE,
TEMPERATURE ABUSE AND STORAGE TIME ON SENSORY,
CHEMICAL, INSTRON AND YIELD PROPERTIES
OF GROUND BEEF PATTIES WITHOUT SOY

PREPARED FOR THE
U.S. ARMY NATICK RESEARCH AND DEVELOPMENT LABORATORIES
NATICK, MASSACHUSETTS 01760

AND THE
FOOD QUALITY ASSURANCE BRANCH
MARKET RESEARCH AND DEVELOPMENT DIVISION
AMS, USDA

BY THE
MEAT SCIENCE RESEARCH LABORATORY
AGRICULTURE RESEARCH SERVICE
U.S. DEPARTMENT OF AGRICULTURE
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OVERALL SUMMARY AND CONCLUSIONS

As was found for beef patties with soy, the variables under study influenced beef patties without soy more than bulk ground beef with soy and beef roasts. Again, this was probably due to: (1) the product (patties) being much smaller and thinner, and (2) the amount of packaging being much less.

Fast freezing rates seemed to produce lighter pigment color. Freezing reduced the presence of light grayish red color. The use of +20°F storage greatly accelerated surface discoloration. Both longer storage periods and +20°F storage resulted in more off-odor. Longer storage and +20°F storage increased freezer burn with this product as it did for patties with soy. Aerobic plate counts decreased slightly with longer storage.

TBA values greatly increased during the first six months of storage as a result of +20°F storage. There were gradual increases for the other storage temperatures with longer storage. Broiled ground beef flavor decreased substantially (rancid flavor replacement) for patties stored at +20°F. There was a slight reduction in ground beef flavor with extended storage. For 0°F and -10°F storage, twelve months of storage was necessary to attain the frequency of rancid flavor detection noted in patties stored at +20°F for only six months. Juiciness decreased slightly with storage.

As with patties with soy, freezing rate exerted a dramatic effect on tenderness properties for patties without soy. The slower the freezing rate, the less tender the product. However, in contrast to patties with soy, this effect was not as dramatic following six months of storage. The biggest decrease in tenderness was simply as a result of freezing, with obviously this effect being most pronounced for the 0°F in 96 hour rate.

Tenderness as determined by Instron measurements showed less effect of freezing rate. Freezing in itself produced a considerable rise in Instron Newton values, especially in the slower freezing rates.

Weight losses due to freezing were variable and not greatly affected by freezing rate. Frozen storage losses were also variable, but increased somewhat with longer storage. During cooking, nonfrozen patties increased in thickness while frozen patties (especially those after storage) decreased in thickness. Percent moisture in raw patties decreased slightly with storage. Percent moisture in cooked patties was considerably higher in patties cooked before freezing compared to those cooked after freezing and/or storage. With the exception of the 0°F in 96 hour rate, more fat was found in cooked patties following freezing than before.

In conclusion, it does not appear that +20°F is a suitable storage temperature even for six months storage. Also, in contrast to patties with soy, patties without soy do not appear capable of being held in frozen storage as long without detrimental changes occurring. Again, similar (although not as dramatic) to what occurred for patties with soy, tenderness in this product was slightly reduced (especially just post-freezing) if slower rates of freezing were employed.

INTRODUCTION

Freezing as a processing procedure is often a necessity for meat products that must undergo transcontinental and oceanic distribution or must be purchased far in advance of consumption due to supply, price and demand. These situations are frequently prevalent in USDA's purchase programs of ground beef for the school lunch program and DOD's procurement of meat products for military establishments. In order to maximize storage life, certain specifications regarding freezing rates, storage temperatures, packaging materials, raw material wholesomeness are applied.

One of the specifications required in the processing of meat products for government procurement deals with freezing rate. Prior to 1982, the requirement was that the product must be frozen to 10°F in 72 hr. Based on a variety of information sources, this requirement was changed in 1982 to 0°F in 72 hr, which reflects a faster rate of freezing. There were some representatives from industry who indicated that this faster freezing rate imposed hardships on their operations and placed them in non-competitive positions. However, there are others (processors and end-users) who maintain that faster freezing rates improve product quality.

In terms of defining what freezing rates were actually being used in industry, a nationwide survey of meat freezing operations was conducted. The survey indicated that a wide range in freezing rates was being practiced; some faster than the 0°F in 72 hr requirement, some slower. Thus, it was decided to evaluate for this project, four different freezing rates; 0°F in 24, 48, 72 and 96 hr. In preliminary studies, it was determined that wide ranges in time (often as much as 36-48 hr to reach 0°F) exist within a pallet load of meat in terms of when 0°F is achieved.

Thus, in order to achieve the uniformity in freezing rate required for this study, it was necessary to freeze product out of the boxes, spaced out on wire mesh racks.

Due to the lack of supportive literature to answer the effects of freezing rate on meat product characteristics, especially in conjunction with frozen storage time and temperature, this project was inaugurated. Four products (beef roasts, bulk ground beef with soy, ground beef patties with soy, ground beef patties without soy) were subjected to the above four freezing rates, two initial storage temperatures (0°F, -10°F), three final storage temperatures (0°F, -10°F, +20°F), temperature abuse of 4 hr at 85°F following 45 and 59 days of storage, and storage times of 0, 6, 9, 12, 18 and 24 months depending on the product. Evaluations included shelflife, microbial, sensory, instrumental texture, weight loss, chemical and cooking properties.

MATERIALS AND METHODS

Processing, Freezing and Storage

The overall project design is shown in Figure 1. Ground beef products were manufactured at a local meat processing establishment. Ground beef ingredients and product formulation conformed with USDA specification PPB 2120. Four batches (1100 pounds per batch) of the ground beef product were processed on four different days, over a four-week period. The final fat content of each batch was adjusted to meet federal interim specification PPB 2120.

All batches were processed (Hollymatic 400) into 3-oz patties stacked 16 high, and boxed in 36 lb boxes. Boxes met USDA specification PPB 1163. The boxes were specifically constructed for ground beef patties, dimensions were 19"x13"x7". After boxing, product was shipped to University of Maryland research freezers within four hours of processing. At the University, stacks of patties were removed from boxes, divided into two stacks, eight high, and placed on wire racks, specifically constructed for the project, within the freezer. Copper constantan thermocouples, attached to temperature recording devices (Campbell Scientific 7, Digitec 1000) were inserted into the geometric centers of 12 patties placed in predetermined locations. An additional six thermocouples, distributed throughout the freezer, recorded ambient air temperature. The freezer thermostat was set at a temperature, predetermined from preliminary freezing trials, to achieve 0°F in 24, 48, 72 or 96 hours. Predetermined temperature adjustments were made at specific time intervals to achieve a given freezing rate. All thermocouple temperatures were monitored and recorded hourly throughout the freezing process.

Figure 1, Project design.

CBP W/ CSC
CBP W/O CSC
CBB W/ CSC
OVEN ROAST

0° F
in 96 hrs.

Diagram illustrating a bus labeled "ABUSE" connected to a block labeled "OK".

[illegible]

GBP - Ground Beef Patties
GGB - Ground Beef Bulk
GSC - Granulated Soy Concentrate
ABUSE - At days 45 and 59
4 hrs. at 85°F

MEAT SCIENCE RESEARCH LABORATORY

January 1983

(FIGURE 1)

After freezing, frozen patties were stacked 16 high, reboxed and placed in storage at 0° or -10°F. After 45 and 60 days of storage at these temperatures, one-half of the boxed product in each rate received temperature abuse (80°F for four hours). The boxed product was laid on pallets outside of the laboratory to simulate temperature abuse encountered in normal military distribution channels. The temperature abuse slightly thawed the product surface. On day 60 of frozen storage, all product (abused and nonabused) was randomly divided and placed into one of three final storage temperatures +20°F, 0°F or -10°F for 6, 9, 12, 18 or 24 months.

Sample Selection

Two boxes of patties representing each freezing rate-initial-final temperature treatment were selected for evaluation at each storage interval.

Microbiological Analysis

Three frozen patties were aseptically selected from each box (top patties of a stack were always excluded). Individual patties were placed in sterile petri dishes prior to analysis. Representative samples (8.3 g) from each of the three patties were combined into a composite sample (25 g) representing each box. The 25 g sample was diluted with 225 ml of peptone water (1.0%, Difco) and blended two minutes in a stomacher (Seward No. 400). Serial dilutions (10^{-3} - 10^{-5}) were prepared from the blended sample and then plated in duplicate in Tryptic soy agar (Difco). Total aerobic plate counts were made after 48 and 72 hours of incubation at 23°C.

Table 1. Microbiological Procedures

Quantitative Determinations	Media	Plating Technique	Incubation	Confirmatory Tests
Aerobic mesophiles	Standard Methods Agar (BBL)	Pour Plates	35°C/48 hr	Gram stain
Aerobic psychrophiles	Standard Methods Agar (BBL)	Pour Plates	15°C/96 hr 4°C/10 days	Gram stain

Shelflife

A trained team of staff members evaluated frozen patties within the box for evidence of shelflife deterioration. Lean color and surface discoloration were evaluated on four patties randomly selected from the interior of patty stacks, while freezer burn was evaluated from top patties of four stacks. Off-odor was evaluated on the entire box. Shelflife characteristics and scoring systems are outlined in Table 2.

Cooking Methodology

Preliminary cooking trials established predetermined cooking times needed to achieve consistent degrees of doneness among cooked patties. Ground beef patties were cooked directly from the frozen state for a total of seven minutes on preheated electric griddles (Farberware #260 SP). All patties were cooked two minutes per side, then an additional three minutes with frequent turning, to avoid excessive browning. Cooked patties were gently blotted prior to weighing and cutting. Degree of doneness scores were evaluated immediately after cutting. All patties achieved a degree of doneness of 2 on an eight-point photographic scale (8 = very rare, 1 = very well done).

Percent Yield

Sixteen patties, randomly selected from each box were weighed just before and after freezing and after frozen storage. Both individual patty and complete stack weights were recorded. Following the cooking procedure, individual patty weights were recorded for cooked yield determination.

$$\% \text{ yield} = 100 - \text{frozen weight} - \frac{\text{cooked weight}}{\text{frozen weight}} \times 100$$

Table 2. Characteristics and scoring systems for shelflife evaluation

Surface Discoloration and Freezer Burn	Color of Lean ^a	Off-odor
7 = 0%	8 = Light grayish red	4 = No off-odor
6 = <10%	7 = Very light cherry red	3 = Slight off-odor
5 = 11-25%	6 = Moderately light cherry red	2 = Moderate off-odor
4 = 26-50%	5 = Cherry red	1 = Extreme off-odor
3 = 51-75%	4 = Slightly dark red	
2 = 76-90%	3 = Moderately dark red	
1 = >90%	2 = Dark red	
	1 = Very dark red	
	0 = Dark purplish black	

^aPhotographic scale adapted from Western Australian beef carcass classification system

Sensory Evaluation

Four patties from each treatment were randomly selected for sensory analysis. An eight-member descriptive attribute panel was trained according to the procedures of Cross et al., (1978). Panelists received two warm pieces (1/8 of a patty) to evaluate for initial tenderness, final tenderness, juiciness, ground beef flavor intensity, presence of other flavors, connective tissue and mouth coating by means of an eight-point structured scale (Table 3). Eight = extremely tender, juicy, intense in flavor, lacking connective tissue and mouth coating; 1 = extremely tough, dry, bland, abundant in connective tissue and very pronounced mouth coating. Panelists met three times a week for two sessions per day. Each session consisted of four to six samples. Serving order of samples within a session was completely random. Panelists were instructed to eat melba toast and drink warm apple juice between samples and they received a ten-minute break between sessions.

Instron Analysis

Six patties per treatment were randomly selected and cooked according to established cooking procedures. Cooked patties were loosely covered and cooled to room temperature (25°C). Each patty was trimmed to a 6.0 cm long section than cut into four equal 3.0 cm² pieces. Each piece was sheared with a straight edge shear blade attached to an Instron Universal Testing Machine (Model 1122), equipped with a micro processor (Microcon II).

Configurational Measurements

Frozen and cooked patty thickness and diameter were recorded on all patties cooked for Instron analysis in order to express shear data as Newtons (expression of peak load in relation to square patty area being sheared) and to evaluate patty shrinkage following cooking.

Table 3. Meat Science Research Laboratory - Ground Beef Form

<u>TENDERNESS</u>	<u>JUICINESS</u>	<u>CONNECTIVE TISSUE AMOUNT</u>
8 - Extremely tender	8 - Extremely juicy	8 - None = 0%
7 - Very tender	7 - Very juicy	7 - Practically none = 1-9%
6 - Moderately tender	6 - Moderately juicy	6 - Traces = 10-19%
5 - Slightly tender	5 - Slightly juicy	5 - Slight = 20-29%
4 - Slightly tough	4 - Slightly dry	4 - Moderate = 30-39%
3 - Moderately tough	3 - Moderately dry	3 - Slightly abundant = 40-49%
2 - Very tough	2 - Very dry	2 - Moderately abundant = 50-59%
1 - Extremely tough	1 - Extremely dry	1 - Abundant = 60%
<u>BEEF FLAVOR INTENSITY</u>	<u>DETECTABLE FLAVORS AND INTENSITY</u>	Initial tenderness - at 5 chews
8 - Extremely intense	(In the off-flavor column, first indicate the number of the flavor component and behind it the intensity using the 8-point intensity scale).	Final tenderness - at 15 chews
7 - Very intense	1. Sour	Connective tissue - at the end of mastication
6 - Moderately intense	2. Bitter	Juiciness - during the first 15 chews
5 - Slightly intense	3. Metallic	Flavor intensity and other flavors - throughout
4 - Slightly bland	4. Sweet	Mouthcoating - following swallowing
3 - Moderately bland	5. Rancid	
2 - Very bland	6. Putrid	
1 - Extremely bland	7. Salty	
<u>MOUTH COATING EFFECT</u>	8. Other	
8 -		
7 - Slight		
6 -		
5 - Moderate		
4 -		
3 - Pronounced		
2 -		
1 - Very pronounced		

Chemical Analyses

TBA

Three frozen patties were randomly selected from each box and allowed to thaw until just pliable prior to analysis. One 10 gram sample from the center of each patty was analyzed in duplicate according to the distillation procedure of Tarladgis et al. (1960).

Expressible Juice

Four frozen patties per box were selected, placed in zip lock bags and allowed to thaw 12 hours at 4°C. One hour before analysis, samples were allowed to warm up to 25°C. Expressible moisture was determined from one sample (400-600 mg), removed from the center of each patty, according to the procedure of Wierbecki and Deatherage (1958) with modification described by Briskey et al. (1959).

Percent Fat and Moisture - Raw

Twenty-five patties from each box were selected and ground three times through a 0.3 cm plate (Hobart 4612) in accordance with A.O.A.C. procedures (1980). Three, 5-gram samples were analyzed from each composite sample. Percent moisture was determined by weight loss following 8-12 hours of drying at 100°C in a vacuum oven (Precision 524). Percent fat was determined on the dried samples by weight loss following 16 hours of extraction with petroleum ether.

Cooked Fat and Moisture

Twenty-four patties were cooked according to procedures described previously for sensory, yield and Instron analyses. Cooked patties were covered tightly, cooled to room temperature (25°C), ground and analyzed according to procedures described for raw patties.

RESULTS AND DISCUSSION

The freezing rate curves for the ground beef patties without soy is depicted in Figure 2. The temperature drop for the 0°F in 96 hour rate proceeded faster than anticipated and approximated the 0°F in 72 hour rate for the first 60 hours.

Prior to freezing, patties selected for the 0°F in 24 hour freezing rate seemed to have more of the lighter colors compared to the formulations selected for the other rates (Table 4). Following freezing, this was still true, but the differences were more dramatic (Table 5). After six months storage, there seemed to be more dark red and moderately dark red but also very light red as a result of +20°F rather than -10°F and 0°F final storage (Table 6). The 0°F in 24 hour frozen product also had more of the light grayish red and less of the very dark red color assigned to it. At six months, temperature abused patties had more very dark red and cherry red color and less very light cherry red color than nonabused product (Table 7). Cherry red color was lower for the 0°F final temperature product at nine months for the 0°F in 72 and 96 hour rates, but not the 0°F in 24 hour rate (Table 8). Very dark red was much higher under 0°F rather than -10°F storage but only for the 0°F in 72 hour rate (Table 8). Again, following twelve months of storage, there were indications of less of the darker colors for patties frozen to 0°F in 24 hours (Table 9). At eighteen months, the faster the freezing rates, the lighter the color scores assigned by the panel (Table 10). For the 0°F in 24 and 48 hour rates, there was less cherry red color. For the 0°F final storage temperature compared to the -10°F final storage temperature.

The greatest change for light grayish red color was simply due to freezing, when for some rate, it reduced from 10% to 0% (Table 11).

Figure 2. Freezing curves to reach 0°F in 24, 48, 72 and 96 hours for ground beef patties without soy.

GROUND BEEF PATTIES WITHOUT SOY

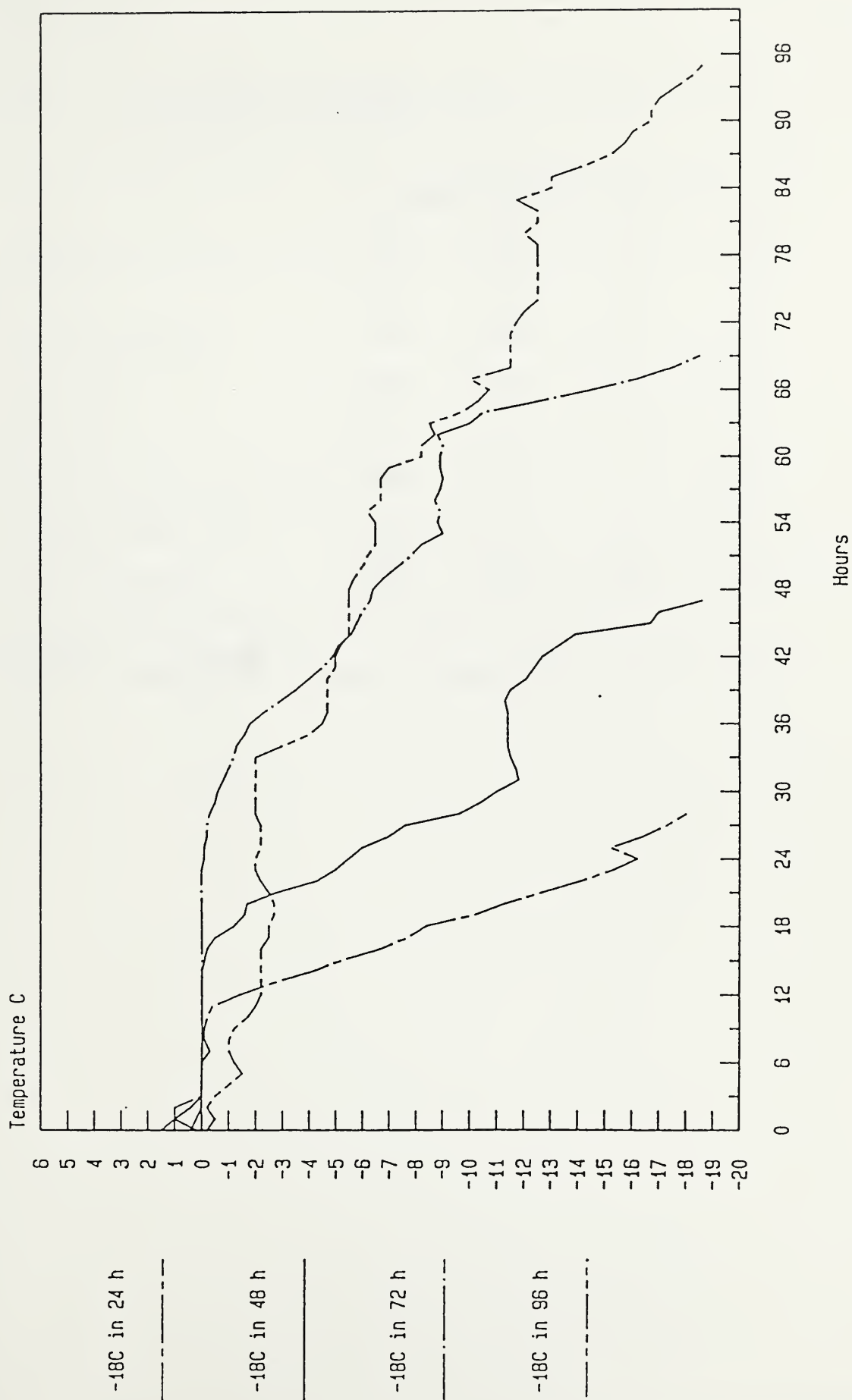


Table 4. Color scores assigned to ground beef patties without soy prior to freezing^a

Color	Freezing Rate, hours to 0°F			
	24	48	72	96
Dark red	0.00	3.37	2.28	0.50
Moderately dark red	6.64	16.83	13.70	12.38
Slightly dark red	19.43	20.67	18.72	20.30
Cherry red	11.85	4.33	10.50	7.92
Moderately light cherry red	21.80	22.12	17.35	20.79
Very light cherry red	22.75	22.12	21.46	21.78
Light grayish red	17.54	10.58	15.98	16.34

Chi-square = 32.92, $P < .017$.

^aValues are percentages of scores assigned within a freezing rate.

Table 5. Color scores assigned to ground beef patties without soy according to freezing rate immediately following freezing^a

Color	Freezing Rate, hours to 0°F			
	24	48	72	96
Blackish purple	0.00	0.00	1.69	0.73
Very dark red	0.00	7.45	11.81	10.95
Dark red	4.64	17.55	19.83	19.34
Moderately dark red	14.95	13.30	14.77	14.96
Slightly dark red	23.20	17.55	16.03	18.61
Cherry red	7.73	8.51	4.64	4.74
Moderately light cherry red	24.23	18.62	19.83	19.34
Very light cherry red	22.68	15.43	11.39	11.31
Light grayish red	2.58	1.60	0.00	0.00

Chi-square = 82.70, $P < .0001$.

^aValues are percentages of scores assigned within a freezing rate.

Table 6. Color scores assigned to ground beef patties without soy according to combinations of freezing rate and final storage temperature following six months storage^a

Freezing rate, hrs to 0°F	Final storage temperature, °F	Color							
		Very dark red	Dark red	Moderately dark red	Slightly dark red	Cherry red	Moderately light cherry red	Very light cherry red	Light grayish red
24	-10	0.85	15.25	16.95	20.34	5.93	19.49	16.10	5.08
	0	0.88	12.39	15.93	20.35	7.96	15.04	19.47	7.96
	+20	0.00	12.57	21.56	19.76	5.39	14.37	21.56	4.79
48	-10	5.74	18.03	18.03	18.85	5.74	19.67	12.30	1.64
	0	2.46	16.39	16.39	19.67	8.20	19.67	16.39	0.82
	+20	1.76	21.18	18.82	17.06	1.76	14.71	24.12	0.59
72	-10	11.11	18.25	15.08	18.25	6.35	17.46	12.70	0.79
	0	12.40	18.60	11.63	18.60	3.88	17.05	14.73	3.10
	+20	5.03	21.38	17.61	20.13	0.00	15.09	18.24	2.52
96	-10	6.73	15.38	12.50	19.23	5.77	19.23	19.23	1.92
	0	6.42	15.60	13.76	18.35	8.26	18.35	18.35	0.92
	+20	1.41	26.06	19.01	13.38	2.11	17.61	20.42	0.00

Chi-square = 147.72, $P < .001$.

a values are percentages of scores assigned within a freezing rate - final storage temperature combination.

Table 7. Color scores assigned to ground beef patties without soy according to temperature abuse following six months storage^a

Color	Temperature Abuse	
	T	N
Very dark red	5.23	1.18
Dark red	17.39	19.47
Moderately dark red	16.10	19.17
Slightly dark red	18.84	17.70
Cherry red	5.80	1.18
Moderately light cherry red	17.55	15.34
Very light cherry red	16.75	23.01
Light grayish red	2.33	2.95

Chi-square = 31.11, $P < .0001$.

^aValues are percentages of scores assigned within an abuse category. T = temperature abuse, N = not temperature abused.

Table 8. Color scores assigned to ground beef patties without soy according to freezing rate - final storage temperature combinations following nine months storage^a

Freezing rate, hrs to 0°F	Final storage temperature, °F	Color							
		Very dark red	Dark red	Moderately dark red	Slightly dark red	Cherry red	Moderately light cherry red	Very light cherry red	Light grayish red
24	-10	1.25	15.00	15.00	20.00	6.25	17.50	20.00	5.00
	0	0.00	10.84	15.66	19.28	8.43	19.28	19.28	7.23
48	-10	3.85	14.10	15.38	20.51	16.67	20.51	8.97	0.00
	0	3.75	16.25	12.50	20.00	12.50	20.00	12.50	2.50
72	-10	7.62	18.10	15.24	19.05	9.52	19.05	11.43	0.00
	0	14.42	18.27	16.35	18.27	7.69	18.27	6.73	0.00
96	-10	3.03	16.16	19.19	20.20	12.12	20.20	9.09	0.00
	0	4.95	20.79	17.82	17.82	5.94	19.80	12.87	0.00

Chi-square = 81.21, $P < .003$.
aValues are percentages of scores assigned within a freezing rate - final storage temperature category.

Table 9. Color scores assigned to ground beef patties without soy according to freezing rate following twelve months storage^a

Color	Freezing Rate, hours to 0°F			
	24	48	72	96
Blackish purple	0.00	0.00	0.42	0.00
Very dark red	2.75	2.13	8.44	4.62
Dark red	12.37	18.72	19.41	16.15
Moderately dark red	14.78	15.74	13.92	15.38
Slightly dark red	19.59	20.00	18.99	17.69
Cherry red	8.59	9.79	4.64	10.38
Moderately light cherry red	19.93	20.00	20.25	19.23
Very light cherry red	18.21	13.19	13.92	15.77
Light grayish red	3.78	0.43	0.00	0.77

Chi-square = 48.60, $P < .002$.

^aValues are percentages of scores assigned within a freezing rate category.

Table 10. Color scores assigned to ground beef patties without soy according to freezing rate - final storage temperature combinations following eighteen months storage

Freezing rate, hrs to 0°F	Final storage temperature, °F	Color							
		Very dark red	Dark red	Moderately dark red	Slightly dark red	Cherry red	Moderately light cherry red	Very light cherry red	Light grayish red
24	-10	0.00	15.63	14.58	19.79	6.25	17.71	19.79	6.25
	0	0.96	13.46	14.42	18.27	9.62	16.35	19.23	7.69
48	-10	7.29	20.83	11.46	20.83	4.17	17.71	16.67	1.04
	0	5.32	20.21	12.77	18.09	6.38	20.21	15.96	1.06
72	-10	14.43	20.62	15.46	17.53	0.00	17.53	13.40	1.03
96	-10	9.20	18.39	18.39	16.09	5.75	18.39	12.64	1.15

Chi-square = 55.23, $P < 0.016$.

aValues are percentages of scores assigned within a freezing rate - final storage temperature category.

Table 11. Incidence of light grayish red color in ground beef patties without soy throughout storage and according to freezing rate and final storage temperature^a

Freezing Rate, hrs to 0°F	Final Storage Temperature, °F	Before freezing	Immediately after freezing, 1 day	Evaluation Time			
				6 mo	9 mo	12 mo	18 mo
24	--	17.54	2.58				
	-10			5.08	5.00	3.65	6.25
	0			7.96	7.23	3.90	7.69
	+20			4.79	2.50	--	--
48	--	10.58	1.60				
	-10			1.64	0.00	0.00	1.04
	0			0.82	2.50	0.75	1.06
	+20			0.59	--	--	--
72	--	15.98	0.00				
	-10			0.79	0.00	0.00	1.03
	0			3.10	0.00	0.00	--
	+20			2.52	--	--	--
96	--	16.34	0.00				
	-10			1.92	0.00	0.00	1.15
	0			0.92	0.00	1.37	--
	+20			0.00	--	--	--

^aValues are percent occurrence of grayish red color among all colors within a storage time-freezing rate-final storage temperature combination.

However, this color was detected for the 0°F in 24 hour product even after eighteen months storage. Cherry red color also became less as a result of freezing the patties (Table 12). This color was more apparent on patties from the faster freezing rates especially for the 0°F final storage temperature. Also, the colder the final storage temperature, the more prevalent this color became.

Table 13 illustrates the general scores assigned to patties for surface discoloration. Especially for 0°F in 72 and 96 hour rates, freezing itself produced considerable discoloration. Advances in storage time and especially the use of +20°F final storage temperature accelerated discoloration. As mentioned above, freezing itself produced more discoloration, which was significant ($P < .05$) for the 0°F in 72 and 96 hour rates (Table 14). However, before freezing, there was less discoloration on patties produced for the 0°F in 96 hour rate vs the 0°F in 24 and 48 hour rates (Table 15). At nine months of storage, more discoloration was noted for the 0°F in 72 hour rate in contrast to the 0°F in 48 hour rate, while at twelve months this freezing rate had more discoloration than both the 0°F in 48 and 96 hour rate. Regardless of temperature abuse, the +20°F final storage resulted in more surface discoloration than -10 and 0°F storage (Table 16). After six months storage, initial and final storage at -10°F produced less discoloration than product initially stored at -10°F and then finally at 0°F. No other differences ($P < .05$) were detected among initial and final temperatures of -10 and 0°F (Table 17). At nine months of storage, patties initially and finally stored at 0°F were rated as being more discolored than patties initially stored at 0°F and finally at -10°F (Table 18). The -10°F final storage temperature produced less surface

Table 12. Incidence of cherry red color in ground beef patties without soy throughout storage and according to freezing rate and final storage temperature^a

Freezing Rate, hrs to 0°F	Final Storage Temperature, °F	Before freezing	Immediately after freezing, 1 day	Evaluation Time			
				6 mo	9 mo	12 mo	18 mo
24	--	11.85	7.73				
	-10			5.93	6.25	10.95	6.25
	0			7.96	8.43	6.49	9.62
	+20			5.39	--	--	--
48	--	4.33	8.51				
	-10			5.74	16.67	12.75	4.17
	0			8.20	12.50	7.52	6.38
	+20			1.76	--	--	--
72	--	10.50	4.64				
	-10			6.35	9.52	4.04	0.00
	0			3.88	7.69	5.07	--
	+20			0.00	--	--	--
96	--	7.92	4.74				
	-10			5.77	12.12	13.16	5.75
	0			8.26	5.94	8.22	--
	+20			2.11	--	--	--

^aValues are percent occurrence of cherry red color among all colors within a storage time-freezing rate-final storage temperature combination.

Table 13. General table illustrating sensory scores for surface discoloration in ground beef patties without soy throughout storage and according to final storage temperature and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Before freezing		4.73 \pm .56	4.71 \pm .77	5.23 \pm .72	5.37 \pm .52
Immediately following freezing, 1 day		4.23 \pm .38	4.21 \pm .54	3.87 \pm .57	3.69 \pm .58
6 months	-10T	3.85 \pm .62	3.44 \pm .56	3.56 \pm .42	3.93 \pm .45
	OT	3.73 \pm .69	3.48 \pm .56	3.72 \pm .56	3.55 \pm .51
	20T	1.17 \pm .28	1.31 \pm .32	1.33 \pm .32	1.15 \pm .23
	20N	1.29 \pm .25	1.23 \pm .25	1.29 \pm .25	1.29 \pm .29
9 months	-10T	3.28 \pm .36	3.28 \pm .37	3.02 \pm .41	3.12 \pm .51
	OT	3.06 \pm .65	3.47 \pm .56	2.52 \pm .50	3.25 \pm .44
12 months	-10T	2.92 \pm .57	3.33 \pm .44	2.92 \pm .70	3.69 \pm .44
	-10N	3.08 \pm .49	3.81 \pm 1.10	2.75 \pm .46	2.92 \pm .38
	OT	2.55 \pm .15	3.12 \pm .53	1.92 \pm .56	2.78 \pm .45
	ON	2.46 \pm .33	2.56 \pm .51	2.34 \pm .68	2.71 \pm .62
18 months	-10N	2.22 \pm .50	2.17 \pm .49	1.95 \pm .48	2.37 \pm .34
	ON	2.20 \pm .39	2.21 \pm .42		

^a Mean \pm S.E. T = temperature abused, N = not temperature abused.

Table 14. Interaction effect of storage time (just before and after freezing) and freezing rate on sensory scores for surface discoloration in ground beef patties without soy

Evaluation time	Freezing rate, hours to 0°F			
	24	48	72	96
Before freezing	4.73 \pm .12bc	4.71 \pm .12bc	5.23 \pm .12ab	5.37 \pm .13a
Immediately following freezing, 1 day	4.23 \pm .12cd	4.21 \pm .17cd	3.87 \pm .13d	3.69 \pm .13d

abcd Any mean comparison with different letters is different ($P < .05$). Mean \pm S.E.

Table 15. Effect of freezing rate on sensory scores for surface discoloration in ground beef patties without soy at various storage intervals

Evaluation time	Freezing rate, hours to 0°F			
	24	48	72	96
Immediately before freezing, 1 day	4.73 \pm .14b	4.71 \pm .14b	5.23 \pm .14ab	5.38 \pm .14a
9 months	3.17 \pm .11ab	3.37 \pm .11a	2.77 \pm .11b	3.19 \pm .11ab
12 months	2.64 \pm .13ab	3.01 \pm .13a	2.39 \pm .13b	3.00 \pm .13a

ab Means on the same line with different letters are different ($P < .05$).
Mean \pm S.E.

Table 16. Effect final storage temperature on sensory scores for surface discoloration in ground beef patties without soy following six months storage

Final storage temperature, °F			
-10	0	20I	20N
3.70 \pm .055a	3.62 \pm .055a	1.24 \pm .055b	1.28 \pm .055b

ab Means on the same line with different letters are different ($P < .05$).
Mean \pm S.E.

Table 17. Interaction effect of initial storage temperature and final storage temperature on sensory scores for surface discoloration in ground beef patties without soy following six months storage

Initial storage temperature, °F	Final storage temperature, °F			
	-10	0	20T	20N
-10	2.88 \pm .14a	2.04 \pm .14bcd	1.77 \pm .14cde	1.38 \pm .14e
0	2.35 \pm .14abc	2.47 \pm .14ab	1.61 \pm .14de	1.50 \pm .14de

abcde Any mean comparison with different letters is different ($P < .05$).

Mean \pm S.E. T = temperature abused, N = not temperature abused.

Table 18. Interactions effect of initial storage temperature and final storage temperature on sensory scores for surface discoloration in ground beef patties without soy following nine months storage

Initial storage temperature, °F	Final storage temperature, °F	
	-10	0
-10	3.15 \pm .11ab	3.21 \pm .11ab
0	3.32 \pm .11a	2.83 \pm .11b

ab Any mean comparison with different letters is different (P<.05). Mean \pm S.E.

Table 19. Effect of final storage temperature on sensory scores for surface discoloration in ground beef patties without soy following twelve months storage

Final storage temperature, °F		
-10T	0T	0N
3.22 \pm .12a	2.59 \pm .12b	2.52 \pm .12b

ab Means on the same line with different letters are different ($P < .05$).

Mean \pm S.E. T = temperature abused, N = not temperature abused.

Table 20. Effect of final storage temperature on sensory scores for surface discoloration in ground beef patties without soy following twelve months storage

Final storage temperature, °F	
-10	0
3.19 \pm .12a	2.72 \pm .12b

ab Difference between means significant ($P < .05$). Mean \pm S.E. Includes both temperature and nontemperature abused product initially stored at -10°F .

Table 21. Effect of various storage time comparisons on sensory scores for surface discoloration in ground beef patties without soy

<u>Evaluation Time</u>	
<u>Immediately following freezing, 1 day</u>	<u>6 months</u>
4.00 \pm .08a	2.40 \pm .08b
<u>Immediately following freezing, 1 day</u>	<u>9 months</u>
4.00 \pm .12a	3.13 \pm .12b
<u>Immediately following freezing, 1 day</u>	<u>12 months</u>
4.00 \pm .17a	2.77 \pm .17b
<u>Immediately following freezing, 1 day</u>	<u>12 months^c</u>
4.00 \pm .18a	2.95 \pm .18b
<u>Immediately following freezing, 1 day</u>	<u>18 months^d</u>
4.00 \pm .11a	2.20 \pm .11b
<u>Immediately following freezing, 1 day</u>	<u>18 months^e</u>
4.22 \pm .17a	2.20 \pm .17b
<u>12 months</u>	<u>18 months</u>
2.93 \pm .14a	2.17 \pm .20b

ab Differences between means on the same line are significant ($P < .05$).
Mean \pm S.E.

^c Includes only -10°F initial storage temperature.

^d Includes only -10°F final storage temperature.

^e Includes only 0°F in 24 and 48 hr freezing rates.

Table 23. Interaction effect of storage time (six, nine months), final storage temperature and rate of freezing on sensory scores for surface discoloration in ground beef patties without soy

Evaluation time, months	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
6	-10	3.85 + .12a	3.44 + .12abc	3.56 + .12abc	3.93 + .12a
	0	3.73 + .12ab	3.48 + .12abc	3.72 + .12ab	3.55 + .12abc
9	-10	3.28 + .12abc	3.28 + .12abc	3.02 + .12cd	3.12 + .12bcd
	0	3.06 + .12bcd	3.47 + .12abc	2.52 + .12d	3.25 + .12abc

abcd Any mean comparison with different letters is different ($P < .05$). Mean + S.E.

Table 24. Interaction of final storage temperature, storage time (six, nine months), and initial storage temperature on sensory scores for surface discoloration in ground beef patties without soy

Final storage temperature, °F	Evaluation time	Initial storage temperature, °F	
		-10	0
-10	6	3.80 + .09a	3.59 + .09abc
	9	3.14 + .09de	3.21 + .09cde
0	6	3.58 + .09abc	3.67 + .09ab
	9	3.32 + .09bcd	2.82 + .09e

abcde Any mean comparison with different letters is different ($P < .05$).
Mean + S.E.

Table 25. Interaction effect storage time (nine, twelve months) and final storage temperature on sensory scores for surface discoloration in ground beef patties without soy

Evaluation time, months	Final storage temperature, °F	
	-10	0
9	3.18 \pm .098a	3.08 \pm .098a
12	3.22 \pm .098a	2.59 \pm .098b

ab Any mean comparison with different letters is different ($P < .05$).
Mean \pm S.E.

Table 26. General table illustrating sensory scores for off-odor in ground beef patties without soy throughout storage and according to final storage temperature and rate of freezing - no statistical analysis^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to °F			
		24	48	72	96
Before freezing		4.00 ± 0.00	4.00 ± 0.00	4.00 ± 0.00	4.00 ± 0.00
Immediately following freezing, 1 day		4.00 ± 0.00	4.00 ± 0.00	4.00 ± 0.00	4.00 ± 0.00
6 months	-10T	3.37 ± .49	3.29 ± .46	3.17 ± .48	3.40 ± .50
	0T	3.44 ± .51	3.25 ± .53	2.83 ± .48	3.20 ± .41
	20T	1.67 ± .56	1.71 ± .46	1.54 ± .51	1.95 ± .39
	20N	1.67 ± .48	1.71 ± .55	1.71 ± .55	1.54 ± .51
9 months	-10T	3.25 ± .45	3.12 ± .34	3.30 ± .57	3.25 ± .44
	0T	3.19 ± .40	3.00 ± .52	3.30 ± .47	3.35 ± .49
12 months	-10T	2.70 ± .47	2.67 ± .49	2.75 ± .45	2.81 ± .40
	-10N	2.50 ± .55	2.75 ± .46	2.50 ± .53	2.50 ± .55
	0T	2.30 ± .47	2.33 ± .49	2.50 ± .52	2.56 ± .63
	0N	2.50 ± .52	2.12 ± .34	2.19 ± .40	2.50 ± .52
18 months	-10N	2.35 ± .50	1.95 ± .22	2.05 ± .51	2.12 ± .34
	0N	2.30 ± .47	2.05 ± .39		

^a Mean ± S.D. T = temperature abused, N = not temperature abused.

Table 27. Interaction effect of final storage temperature and rate of freezing on sensory scores for off-odor in ground beef patties without soy following six months storage

Final storage temperature, °F	Freezing rate, hours to 0°F			
	24	48	72	96
-10	3.37 ± .089a	3.29 ± .089ab	3.17 ± .089ab	3.40 ± .089a
0	3.44 ± .089a	3.25 ± .089ab	2.83 ± .089b	3.20 ± .089ab
20T	1.67 ± .089c	1.71 ± .089c	1.54 ± .089c	1.95 ± .089c
20N	1.67 ± .089c	1.71 ± .089c	1.71 ± .089c	1.54 ± .089c

abc Any mean comparison with different letters is different (P<.05).

Mean ± S.E. T = temperature abused, N = not temperature abused.

Table 28. Interaction effect of initial storage temperature and final storage temperature on sensory scores for off-odor in ground beef patties without soy following twelve months storage

Initial storage temperature, °F	Final storage temperature, °F		
	-10T	0T	0N
-10	2.55 \pm .074b	2.51 \pm .074b	2.27 \pm .074b
0	2.91 \pm .074a	2.33 \pm .074b	2.38 \pm .074b

ab Any mean comparison with the same letters is not different ($P > .05$)
Mean \pm S.E. T = temperature abuse, N = not temperature abused.

Table 29. Effect of freezing rate on sensory scores for off-odor in ground beef patties without soy following eighteen months storage

<u>Freezing rate, hours to 0°F</u>	
<u>24</u>	<u>48</u>
2.32 \pm .060a	2.00 \pm .060b

ab Difference between means significant ($P < .05$). Mean \pm S.E.

Storage time comparisons with values for off-odor obtained just post-freezing revealed more off-odor (Table 30). Patties frozen to 0°F in 72 hours had more off-odor at six months compared to 0°F in 24 hour product (Table 31). This difference was not noted at nine months. Following nine months of storage, most of the nonabused-initial-final temperature combinations had more off-odor than just post-freezing, while these comparisons were nonsignificant ($P > .05$) for temperature abused product (Table 32). Between nine and twelve months, all the initial-final temperature combinations showed an increase in off-odor with the exception of patties stored initially at 0 and finally at -10°F (Table 33).

Freezer burn appeared to be influenced (increased) most by +20°F final storage and longer periods of storage (Table 34). When evaluations occurred at six months, the 0°F final storage temperature produced more freezer burn than -10°F only if the initial storage temperature was -10°F. Also +20°F temperature abused patties did not differ in freezer burn from 0°F final temperature storage when initial storage was 0°F (Table 35). At twelve months, -10°F final temperature abused product displayed less freezer burn than 0°F final non-temperature abused product (Table 36). Following eighteen months of storage, less freezer burn was detected on the surface of 0°F in 24 hour frozen patties vs patties frozen to 0°F in 48 hours (Table 37). Also, at eighteen months, surprisingly, 0°F initial storage temperature resulted in less freezer burn than -10°F initial temperature (Table 38).

Increases in storage time, as would be expected, produced more freezer burn (Table 39). Following six months of storage, the only initial-final temperature combination to not have any more freezer burn to that found

Table 30. Effect of various storage time comparisons on sensory scores for off-odor in ground beef patties without soy

<u>Evaluation Time</u>	
<u>Immediately following freezing, 1 day</u>	<u>6 months</u>
4.00 \pm .063a	2.47 \pm .063b
<u>Immediately following freezing, 1 day</u>	<u>9 months</u>
4.00 \pm .070a	3.22 \pm .070b
<u>Immediately following freezing, 1 day</u>	<u>12 months</u>
4.00 \pm .11a	2.47 \pm .11b
<u>Immediately following freezing, 1 day</u>	<u>18 months^c</u>
4.00 \pm .09a	2.16 \pm .09b
<u>Immediately following freezing, 1 day</u>	<u>18 months^d</u>
4.00 \pm .07a	2.11 \pm .07b
<u>12 months^e</u>	<u>18 months^e</u>
2.42 \pm .08a	2.12 \pm .11b

ab Difference between means on the same line significant ($P < .05$).
Mean \pm S.E.

^c Includes just 0°F in 24 and 48 hr freezing rate.

^d Includes just -10°F final storage temperature.

^e Includes just -10°F final storage temperature and non temperature abused product

Table 31. Interaction effect of storage time (six, nine months) and freezing rate on sensory scores for off-odor in ground beef patties without soy

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
6	3.41 \pm .065a	3.27 \pm .065ab	3.00 \pm .065b	3.30 \pm .065ab
9	3.22 \pm .065ab	3.06 \pm .065b	3.30 \pm .065ab	3.30 \pm .065ab

ab Any mean comparison with the same letters is not different ($P > .05$).

Mean \pm S.E.

Table 32. Interaction effect of storage time (immediately following freezing, nine months) and temperature abuse on sensory scores for off-odor in ground beef patties without soy

9 months storage				
Immediately following freezing, 1 day abuse	Temperature	Initial storage temperature, °F =		0
		-10	-10	
4.00 ± .14a	T	Final storage temperature, °F =		0
		-10	-10	
		3.67 ± .14ab	3.67 ± .14ab	3.42 ± .14abc
	N	3.08 ± .14bcd	3.17 ± .14abcd	2.50 ± .14d

abcd Any mean comparison with different letters is different (P<.05), T = temperature abused, N = not temperature abused.

Table 33. Interaction effect of storage time (nine, twelve months), initial storage temperature, final storage temperature on sensory scores for off-odor in ground beef patties without soy

Evaluation time, months	Initial storage temperature, °F	Final storage temperature, °F	
		-10	0
9	-10	3.27 \pm .06a	3.15 \pm .06ab
	0	3.19 \pm .06ab	3.27 \pm .06a
12	-10	2.55 \pm .06c	2.51 \pm .06c
	0	2.91 \pm .06b	2.33 \pm .06c

abc Any mean comparison with different letters is different ($P < .05$).

Mean \pm S.E.

Table 34. General table illustrating sensory scores for freezer burn in ground beef patties without soy throughout storage and according to final storage temperature and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Before freezing					
Immediately following freezing, 1 day		3.18 \pm .58	3.29 \pm .66	2.87 \pm .63	3.41 \pm .60
6 months	-10T	2.63 \pm .83	2.67 \pm .69	2.56 \pm .76	2.60 \pm .31
	0T	2.30 \pm .74	2.54 \pm .61	2.12 \pm .42	2.05 \pm .46
	20T	1.65 \pm .37	1.69 \pm .55	1.56 \pm .47	1.87 \pm .48
	20N	1.60 \pm .47	1.33 \pm .35	1.45 \pm .26	1.37 \pm .34
9 months	-10T	2.47 \pm .22	2.78 \pm .48	2.27 \pm .66	2.55 \pm .36
	0T	2.30 \pm .44	2.23 \pm .58	2.32 \pm .49	2.61 \pm .71
12 months	-10T	2.40 \pm .68	2.56 \pm .90	2.58 \pm .19	2.31 \pm .63
	-10N	2.41 \pm .49	2.94 \pm .62	2.50 \pm .46	2.42 \pm .20
	0T	2.37 \pm .51	1.58 \pm .47	2.25 \pm .45	2.16 \pm .65
	0N	2.21 \pm .50	1.75 \pm .45	2.25 \pm .58	1.87 \pm .43
18 months	-10N	2.23 \pm .33	1.67 \pm .52	2.12 \pm .60	1.72 \pm .48
	0N	2.02 \pm .57	1.57 \pm .29		

^a Mean \pm S.D. T = temperature abused. N = not temperature abused.

Table 35. Interaction effect of final storage temperature and initial storage temperature on sensory scores for freezer burn in ground beef patties without soy following six months storage

Final storage temperature, °F	Temperature abuse	Initial storage temperature, °F	
		-10	0
-10	T	2.88 \pm .13a	2.35 \pm .13abc
0	T	2.04 \pm .13bcd	2.47 \pm .13ab
+20	T	1.77 \pm .13cde	1.61 \pm .13de
+20	N	1.38 \pm .13e	1.50 \pm .13de

abcde Any mean comparison with different letters is different ($P < .05$).

Mean \pm S.E. T = temperature abused, N = not temperature abused.

Table 36. Effect of final storage temperature on sensory scores for freezerburn in ground beef patties without soy following twelve months storage

Final storage temperature, °F		
-10T	0T	0N
2.46 \pm .12a	2.09 \pm .12ab	2.02 \pm .12b

ab Means on the same line with the same letters are not different ($P > .05$). Mean \pm S.E. T = temperature abuse. N = not temperature abused.

Table 37. Effect of freezing rate on sensory scores for freezer burn in ground beef patties without soy following eighteen months storage

<u>Freezing rate, hours to 0°F</u>	
<u>24</u>	<u>48</u>
2.13 \pm .12a	1.62 \pm .12b

ab Difference between means significant ($P < .05$). Mean \pm S.E.

Table 38. Effect of initial storage temperature on sensory scores for freezer burn in ground beef patties without soy following eighteen months storage

Initial storage temperature, °F	
-10	0
1.56 \pm .085b	2.23 \pm .069a

ab Difference between means significant ($P < .05$). Mean \pm S.E. Includes just -10°F final storage temperature.

Table 39. Effect of various storage time comparisons on sensory scores for freezer burn in ground beef patties without soy

<u>Evaluation Time</u>	
<u>Immediately following freezing, 1 day</u>	<u>6 months</u>
3.19 \pm .14a	2.00 \pm .14b
<u>Immediately following freezing, 1 day</u>	<u>9 months</u>
3.19 \pm .14a	2.44 \pm .14b
<u>Immediately following freezing, 1 day</u>	<u>12 months^c</u>
3.19 \pm .18a	2.34 \pm .18b
<u>Immediately following freezing, 1 day</u>	<u>12 months</u>
3.19 \pm .17a	2.19 \pm .17b
<u>Immediately following freezing, 1 day</u>	<u>18 months^d</u>
3.19 \pm .09a	1.90 \pm .09b
<u>Immediately following freezing, 1 day</u>	<u>18 months^e</u>
3.23 \pm .23a	1.88b
<u>12 months</u>	<u>18 months</u>
2.26 \pm .12a	1.67 \pm .18b

ab Differences between means on the same line significant ($P < .05$).
Mean \pm S.E.

^c Includes only -10°F initial storage temperature.

^d Includes only -10°F final storage temperature.

^e Includes only 0°F in 24 and 48 hr freezing rates.

post-freezing was the use of -10°F for both initial and final storage (Table 40). Nonabused, -10°F final stored patties were similar at twelve months in freezer burn to patties evaluated just following freezing (Table 41). After eighteen months of storage, initial storage at either -10 or 0°F for 0°F in 24 hour product failed to increase freezer burn over that noted just after freezing (Table 42). Increases did occur for the 0°F in 48 and 96 hour rates.

General data pertaining to aerobic plate counts are shown in Table 43. Counts did not differ greatly as a result of the study, although there was some slight reduction as storage time advanced. Before the initiation of the project and at all evaluation times thereafter, product selected for the 0°F in 24 and 48 hour rates had lower counts than the other two rates (Table 44). Adjusting these data for pre-freezing differences removed much of the freezing rate effects; however, patties frozen to 0°F in 96 hours still had higher counts at six, nine and twelve months (Table 45). Following six months storage, patties subjected to $+20^{\circ}\text{F}$ storage had lower APC than patties held at the other two final temperatures (Table 46). At nine months, product initially stored at -10°F had a very slight increase in counts over 0°F initial storage (Table 47). At twelve months, patties held at -10°F final temperature were slightly higher in APC than 0°F stored patties (Table 48). After twelve months of storage, patties frozen to 0°F in 24 hours were higher in bacterial counts than 0°F in 48 hour frozen patties, only if finally stored at 0°F and not temperature abused (Table 49). Adjusting these data for pre-freezing rate effects eliminated this difference (Table 50). After eighteen months, patties frozen to 0°F in 48 hours had lower counts than patties frozen to 0°F in 24 hours (Table 51).

Table 40. Effect of storage time (immediately following freezing, six months) on sensory scores for freezer burn in ground beef patties without soy

		6 months storage			
		Initial storage temperature, °F =		-10	
				0	
		Final storage temperature, °F =		-10	
				20	
				-10	
				20	
				-10	
				20	
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Table 41. Effect of storage time (immediately following freezing, twelve months) on sensory scores for freezer burn in ground beef patties without soy

Immediately following freezing, 1 day	12 months storage			
	Temperature abuse		N	
	T			
	Final storage temperature, °F =			
	-10	0	-10	0
3.19 ± .16a	2.47 ± .16b	2.36 ± .16b	2.57 ± .16ab	1.95 ± .16b

ab Means on the same line with the same letters are not different ($P > .05$). Mean ± S.E. Includes only -10°F initial storage temperature. T = temperature abused. N = not temperature abused.

Table 42. Interaction effect of storage time (immediately following freezing, eighteen months), initial storage temperature and rate of freezing on sensory scores for freezer burn in ground beef patties without soy

Evaluation time	Initial storage temperature, °F	Freezing rate, hours to 0°F		
		24	48	72
Immediately following freezing, 1 day		3.18 + .15ab	3.29 + .15a	2.87 + .15abc
				3.42 + .15a
18 months	-10	2.25 + .15bcd	1.25 + .15e	1.44 + .23de
	0	2.22 + .15bcde	2.10 + .15cde	2.55 + .15abc
				1.37 + .15de
				2.06 + .15cde

abcde Any mean comparison with different letters is different ($P < .05$). Mean + S.E.

Table 43. General table illustrating aerobic plate counts for ground beef patties without soy throughout storage times and according to final storage temperatures and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Before freezing		5.87 ± .07	5.67 ± .07	6.32 ± .09	6.16 ± .09
Immediately after freezing, 1 day		5.58 ± .06	5.51 ± .07	6.19 ± .19	6.05 ± .08
6 months	-10 T	5.54 ± .07	5.16 ± .10	5.91 ± .16	5.90 ± .08
	0 T	5.47 ± .06	5.17 ± .19	5.97 ± .04	5.93 ± .04
	20 T	5.13 ± .12	4.72 ± .08	5.56 ± .09	5.70 ± .12
	20 N	5.03 ± .13	4.90 ± .25	5.47 ± .18	5.69 ± .22
9 months	-10 T	5.29 ± .01	5.05 ± .10	5.79 ± .17	5.68 ± .08
	0 T	5.30 ± .04	4.98 ± .05	5.82 ± .07	5.73 ± .08
12 months	-10 T	5.21 ± .12	4.90 ± .16	5.70 ± .11	5.74 ± .14
	-10 N	5.34 ± .01	4.93 ± .08	5.72 ± .15	5.90 ± .04
	0 T	5.08 ± .11	4.93 ± .09	5.65 ± .03	5.44 ± .12
	0 N	5.33 ± .07	4.91 ± .10	5.54 ± .09	5.55 ± .05
18 months	-10 N	5.18 ± .09	4.99 ± .11	5.68 ± .09	5.72 ± .14
	0 N	5.18 ± .07	5.00 ± .18	--	--

^aMeans ± S.D. Values are \log_{10}/g . T = temperature abused; N = not temperature abused.

Table 44. Effect of rate of freezing on aerobic plate counts for ground beef patties without soy at various storage times

Evaluation time	Freezing Rate, hours to 0°F			
	24	48	72	96
Before freezing	5.87 ± .027c	5.67 ± .027d	6.32 ± .028a	6.16 ± .027b
After freezing				
1 day	5.58 ± .038b	5.51 ± .038b	6.19 ± .038a	6.05 ± .038a
6 months	5.29 ± .035b	4.99 ± .035c	5.73 ± .035a	5.80 ± .035a
9 months ^e	5.29 ± .026b	5.01 ± .026c	5.80 ± .026a	5.70 ± .026a
12 months ^f	5.25 ± .035b	4.93 ± .035c	5.64 ± .035a	5.70 ± .035a
18 months ^g	5.18 ± .056b	4.99 ± .056b	5.68 ± .079a	5.72 ± .056a

abcd Means on the same line within storage times with different letters are different.

(P<.05); Mean ± S.E. Values are log₁₀/g

^eIncludes temperature abused product.

^fIncludes both temperature abused and not temperature abused product. Includes only

-10°F initial storage temperature product.

^gIncludes just non-temperature abused product. Includes only -10°F final storage temperature product.

Table 45. Effect of freezing rate on aerobic plate count for ground beef patties without soy following various storage periods - data adjusted for differences prior to freezing

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
6	5.42 \pm .035b	5.32 \pm .035b	5.42 \pm .035b	5.66 \pm .035a
9	5.42 \pm .026b	5.34 \pm .026c	5.49 \pm .026ab	5.55 \pm .026a
12 ^d	5.38 \pm .035b	5.26 \pm .035b	5.33 \pm .035b	5.55 \pm .035a

abc Means on the same line with different letters are different (P<.05). Mean \pm S.E.

d Includes just -10°F initial storage temperature.

Table 46. Effects of final storage temperature on aerobic plate counts for ground beef patties without soy following six months storage

<u>Final Storage Temperature, °F</u>			
<u>-10T</u>	<u>0T</u>	<u>+20T</u>	<u>+20N</u>
5.63 \pm .035a	5.63 \pm .035a	5.28 \pm .035b	5.27 \pm .035b

ab Means on the same line with different letters are different ($P < .05$); Mean \pm S.E. Values are \log_{10}/g .

Table 47. Effect of final storage temperature on aerobic plate counts for ground beef patties without soy following nine months of storage

<u>Initial storage temperature, °C</u>	
<u>-10</u>	<u>0</u>
5.49 \pm .018a	5.42 \pm .018b

ab Difference between means are significant ($P < .05$); Mean \pm S.E. Values are \log_{10}/g .

Table 48. Effects of final storage temperature on aerobic plate counts for ground beef patties without soy following twelve months of storage

<u>Final Storage Temperature, °C</u>	
<u>-10</u>	<u>0</u>
5.46 \pm .025a	5.30 \pm .025b

ab Difference between means was significant ($P < .05$); Mean \pm S.E. Values are \log_{10}/g . Includes only -10°F initial storage temperature. Includes both temperature abused and nonabused product.

Table 49. Interaction effect of final storage temperature and rate of freezing on aerobic plate counts for ground beef patties without soy following 12 months of storage

Final Storage Temperature, °C	Freezing Rate, hours to 0°F		
	24	48	72
-10 T	5.21 + .055cde	4.90 + .055e	5.70 + .055a
0 T	5.08 + .055de	4.92 + .055e	5.65 + .055ab
N	5.33 + .055bcd	4.90 + .055e	5.54 + .055abc
			5.74 + .055a
			5.44 + .055abc
			5.55 + .055abc

abcde Any mean comparisons with different letters are different ($P < .05$). Mean + S.E.; Values are \log_{10}/g . T = temperature abused; N = not temperature abused.

Table 50. Interaction effect of final storage temperature and rate of freezing on aerobic plate counts in ground beef patties without soy following twelve months storage -- data adjusted for differences prior to freezing

Final storage temperature, °F	Freezing rate, hours to 0°F			
	24	48	72	96
-10T	5.34 ± .055ab	5.23 ± .055b	5.39 ± .055ab	5.59 ± .055a
0T	5.21 ± .055b	5.25 ± .055ab	5.34 ± .055ab	5.29 ± .055ab
0N	5.46 ± .055ab	5.23 ± .055b	5.23 ± .055b	5.40 ± .055ab

ab Any mean comparison with the same letters is not different (P>.05). Mean ± S.E. T = temperature abused, N = not temperature abused.

Table 51. Effects of rate of freezing on aerobic plate counts for ground beef patties without soy following 18 months of storage

<u>Freezing rate, hours to 0°F</u>	
<u>24</u>	<u>48</u>
5.18 \pm .054a	4.99 \pm .054b

ab Difference between means are significant ($P < .05$). Mean \pm S.E. Values are \log_{10}/g . Includes only nonabused product.

Freezing in itself slightly reduced APC (Table 52). Storage time comparisons (Table 53) with just post-freezing revealed decreases in APC with storage time. At six months, all patties stored initially at 0°F and those stored at +20°F from -10°F initial storage had lower counts than that observed just after freezing (Table 54). Between six and nine months, counts decreased (Table 55). Between nine and twelve months of storage, no changes were found except for a decrease in counts for the 0°F in 96 hour frozen patties finally stored at 0°F (Table 56). Adjusting these data for pre-freezing differences failed to change these results (Table 57).

The next set of data illustrates changes in TBA values. Values substantially increased as a result of +20°F storage and to some degree with longer storage (Table 58). At six months of storage, regardless of freezing rate, +20°F final storage produced higher TBA values (Table 59). For patties frozen to 0°F in 48 hours those that were stored at +20°F and temperature abused had lower TBA values than those not abused. Following twelve months of storage, -10°F initial storage generated higher TBA than 0°F storage (Table 60). Also at twelve months, nonabused patties had higher TPA values than temperature abused patties when final temperature was 0°F (Table 61).

Table 62 shows with the exception of a TBA decrease just due to freezing, storage produced higher values compared to just post-freezing. Following six months, TBA values for patties stored under any initial-final temperature combination using -10 and 0°F did not differ from those noted just after freezing, however, +20°F values were all much higher (Table 63). TBA values increased between nine and twelve months for patties initially stored at -10°F, but not 0°F (Table 64).

Table 52. Effects of freezing on aerobic plate counts for ground beef patties without soy

<u>Evaluation Time</u>	
<u>Before freezing</u>	<u>Immediately after freezing, 1 day</u>
6.01 \pm .015a	5.83 \pm .022b

ab Difference between means significant (P<.05); Mean \pm S.E. Values are log₁₀/g.

Table 53. Effects of storage time (comparisons of immediately following freezing with various storage times, months) on aerobic plate counts for ground beef patties without soy

<u>Evaluation Time Comparisons</u>	
<u>Immediately following freezing, 1 day</u>	<u>6 months</u>
5.83 \pm .026a	5.45 \pm .026b
<u>Immediately following freezing, 1 day</u>	<u>9 months</u>
5.83 \pm .023a	5.45 \pm .023b
<u>Immediately following freezing, 1 day</u>	<u>12 months</u>
5.83 \pm .025a	5.33 \pm .025b
<u>Immediately following freezing, 1 day</u>	<u>18 months</u>
5.83 \pm .034a	5.40 \pm .034b ^c
<u>Immediately following freezing, 1 day</u>	<u>18 months</u>
5.83 \pm .043a	5.09 \pm .043b ^d

ab Means on the same line with different letters are different; Means \pm S.E. Values are \log_{10}/g .

^cIncludes only -10°F final storage temperature product.

^dIncludes only 0°F in 24 and 48 hr freezing rate product.

Table 54. Effect of storage time (immediately following freezing, six months) on aerobic plate counts for ground beef patties without soy

		6 months storage			
Immediately after freezing, 1 day	Abuse	Initial storage temperature, °F =	-10		
		Final storage temperature, °F =	-10	0	+20
5.83 ± .048a	T N	5.66 ± .048ab	5.67 ± .048ab	5.59 ± .048b	5.28 ± .048c 5.31 ± .048c
				5.60 ± .048b	5.28 ± .048c 5.23 ± .048c

abc Any mean comparisons with different letters are different ($P < .05$); Mean ± S.E.. Values are log₁₀/g.
T = temperature abused, N = not temperature abused.

Table 55. Effects of storage time (six, nine months) on aerobic plate counts for ground beef patties without soy

<u>Evaluation Time, months</u>	
<u>6</u>	<u>9</u>
5.63 \pm .016a	5.45 \pm .016b

ab Differences between means are significant (P<.05); Mean \pm S.E. Values are log₁₀/g.

Table 56. Interaction effect of final storage temperature, storage time (nine, twelve months) and rate of freezing on aerobic plate counts for ground beef patties without soy

Final Storage Temperature, °F	Evaluation Time	Freezing Rate, hours to 0°F			
		24	48	72	96
-10	9	5.29 + .05cd	5.05 + .05ef	5.79 + .05a	5.68 + .05ab
-10	12	5.22 + .05cde	4.90 + .05f	5.70 + .05ab	5.74 + .05a
0	9	5.30 + .05cd	4.98 + .05ef	5.82 + .05a	5.73 + .05a
0	12	5.08 + .05def	4.93 + .05f	5.65 + .05ab	5.44 + .05bc

abcdef Any mean comparisons with different letters are different. Mean \pm S.E. Values are \log_{10}/g .

Table 57. Interaction effect of storage time (nine, twelve months); final storage temperature and rate of freezing on aerobic plate counts for ground beef patties without soy -- data adjusted for differences prior to freezing

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
9	-10	5.42 ± .048abc	5.38 ± .048abc	5.48 ± .048abc	5.52 ± .048ab
	0	5.43 ± .048abc	5.31 ± .048c	5.51 ± .048ab	5.58 ± .048a
12	-10	5.34 ± .048abc	5.23 ± .048bc	5.39 ± .048abc	5.59 ± .048a
	0	5.21 ± .048c	5.25 ± .048bc	5.34 ± .048abc	5.29 ± .048bc

abc Any mean comparison with the same letters is not different (P>.05). Mean ± S.E.

Table 58. General table illustrating TBA values in ground beef patties without soy throughout storage and according to final storage temperature and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Before freezing		2.62 ± .26	2.00 ± .25	2.76 ± .5	2.13 ± .41
Immediately following freezing, 1 day		1.92 ± .19	1.82 ± .28	2.1 ± .45	1.97 ± .15
6 months	-10T	2.90 ± .78	2.26 ± .28	2.88 ± .45	2.75 ± .34
	OT	3.24 ± .99	2.52 ± .44	3.37 ± .43	2.57 ± .14
	20T	8.88 ± 2.07	6.47 ± 1.4	8.87 ± 2.22	7.00 ± .87
	20N	8.40 ± 1.54	8.95 ± 1.29	9.84 ± 1.70	7.46 ± 1.17
9 months	-10T	2.83 ± .77	2.77 ± .54	3.20 ± .64	2.77 ± .33
	OT	3.26 ± .47	2.31 ± .33	3.10 ± .64	2.79 ± .31
12 months	-10T	3.38 ± .74	3.26 ± .76	4.14 ± .75	3.25 ± .56
	-10N	3.22 ± .79	4.21 ± .56	3.53 ± .47	3.35 ± .29
	OT	3.60 ± .85	3.20 ± .44	3.59 ± .74	3.22 ± .44
	ON	3.98 ± .79	4.44 ± .93	3.85 ± .49	3.5 ± .21
18 months	-10N	3.71 ± 1.06	3.9 ± .53	4.82 ± 1.01	4.92 ± .94
	ON	3.91 ± .92	4.06 ± 1.35	-----	-----

^a Mean ± S.D. T=temperature abused. N=not temperature abused.

Table 59. Interaction effect of final storage temperature and rate of freezing on TBA values for ground beef patties without soy following six months of storage

Final storage temperature, °F	Freezing rate, hours to 0°F			
	24	48	72	96
-10T	2.90 \pm .37d	2.26 \pm .37d	2.88 \pm .37d	2.75 \pm .37d
0T	3.24 \pm .37d	2.52 \pm .37d	3.67 \pm .37d	2.57 \pm .37d
20T	8.88 \pm .37ab	6.47 \pm .37c	8.87 \pm .37ab	7.00 \pm .37bc
20N	8.40 \pm .37ab	8.95 \pm .37ab	9.84 \pm .37a	7.46 \pm .37b

abcd Any mean comparison with different letters is different ($P < .05$).

Mean \pm S.E. T=temperature abused. N=not temperature abused.

Table 60. Effect of initial storage temperature on TBA values for ground beef patties without soy following twelve months storage

Initial storage temperature, °F	
-10	0
3.80 \pm .087a	3.44 \pm .087b

ab Difference between means significant ($P < .05$). Mean \pm S.E.

Table 61. Effect of final storage temperature on TBA values for ground beef patties without soy following twelve months storage

Final storage temperature, °F		
-10T	0T	0N
3.51 \pm .11b	3.4 \pm .11b	3.94 \pm .11a

ab Means on the same line with different letters are different ($P < .05$).

Mean \pm S.E. T=temperature abused. N=not temperature abused.

Table 62. Effect of various storage time comparisons on TBA values for ground beef patties without soy

Evaluation time	
<u>Immediately before freezing</u> 2.38 ± .13a	<u>Immediately following freezing, 1 day</u> 1.90 ± .13b
<u>Immediately following freezing, 1 day</u> 1.90 ± .29b	<u>6 months</u> 5.52 ± .29a
<u>Immediately following freezing, 1 day</u> 1.90 ± .29b	<u>9 months</u> 2.88 ± .18a
<u>Immediately following freezing, 1 day</u> 1.90 ± .17b	<u>12 months^c</u> 3.62 ± .17a
<u>Immediately following freezing, 1 day</u> 1.91 ± .19b	<u>12 months^d</u> 3.74 ± .19a
<u>Immediately following freezing, 1 day</u> 1.89 ± .40b	<u>18 months^e</u> 3.89 ± .40a
<u>Immediately following freezing, 1 day</u> 2.02 ± .27b	<u>18 months^f</u> 4.41 ± .27a

ab Means on same line with different letters are different ($P < .05$). Mean ± S.E.

c Includes both temperature and nontemperature abused product.

d Includes just -10°F initial storage temperature product.

e Includes only 0°F in 24 and 48 hour freezing rate product.

f Includes all four freezing rates, but only nontemperature abused product.

Table 63. Effect of storage time (immediately following freezing, six months) on TBA values for ground beef patties without storage

		6 months			
Immediately after freezing, 1 day	Temperature abuse	Initial storage temperature, °F =		Final storage temperature, °F =	
		-10	0	-10	0
1.93 ± .29b	T N	2.66 ± .26b	2.71 ± .26b	7.67 ± .26a 8.68 ± .26a	2.74 ± .26b 3.14 ± .26b

ab Any mean comparison with the same letter is not different ($P > .05$). Mean ± S.E. T=temperature abused. N=not temperature abused.

Table 64 . Interaction effect of storage time (nine, twelve months) and initial storage temperature on TBA values for ground beef patties without soy

Evaluation time, months	Initial storage temperature, °F	
	-10	0
9	2.86 \pm .12b	2.89 \pm .12b
12	3.71 \pm .12a	3.2 \pm .12b

ab Any mean comparison with different letters is different ($P < .05$).

Mean \pm S.E.

The intensity of ground beef flavor decreased as a result of +20°F storage and longer storage time (Table 65). At six months, the colder the final storage temperature, the more intense was ground beef flavor (Table 66). Obviously, much of this decrease, which can be observed in the next section of the report, was due to the appearance of other flavors (rancid) typically associated with storage. At six months for +20°F stored product, temperature abuse decreased TBA values. The opposite of this occurred for 0°F final stored product at twelve months of storage (Table 67). At nine months, 0°F in 72 hour frozen patties were highest in intensity of ground beef flavor, while at twelve months, both 0°F in 72 and 24 hour patties were highest in intensity (Table 68).

Longer periods of storage, mainly compared with just post-freezing, showed reductions in the ground beef flavor intensity of cooked patties (Table 69). At six months of storage, both 0 and +20°F final storage produced lower ground beef flavor intensity (Table 70). Between six and nine months, there were indications (nonsignificant, $P > .05$) that flavor intensity decreased for 0°F in 24 hour stored patties, while increasing for 0°F in 72 hour stored patties (Table 71). After nine months of storage, only product initially stored at -10°F and finally at 0°F was lower in ground beef flavor intensity than patties evaluated just after freezing (Table 72).

Following six months of storage, rancid was the most prevalent other detectable flavor noted (Table 73). It must be pointed out that for example the values don't mean that 80% of all evaluations or samples had some level of rancidity, but rather that 80% of all the detectable flavors for a particular freezing rate-temperature combination, etc., were rancid.

Table 65. General lairage characteristics of ground beef patties without soy throughout storage and according to final storage temperature and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Before freezing		4.14 ± 1.22	4.47 ± .79	4.48 ± .73	4.45 ± .90
Immediately following freezing, 1 day		4.75 ± .75	4.45 ± .96	4.17 ± .88	3.96 ± .66
6 months	-10T	4.47 ± .83	3.86 ± .79	3.87 ± .60	3.98 ± .83
	0T	4.00 ± .82	3.65 ± .75	3.67 ± .82	3.89 ± .91
	20T	2.95 ± .61	2.87 ± .85	2.89 ± .73	3.07 ± .63
	20N	3.37 ± .60	3.25 ± .87	2.96 ± .86	3.29 ± .71
9 months	-10T	3.85 ± .71	4.02 ± .85	4.52 ± .63	3.91 ± .68
	0T	3.82 ± .59	3.95 ± .73	4.11 ± .75	3.70 ± .74
12 Months	-10T	3.92 ± .54	3.72 ± .60	4.02 ± .68	3.68 ± .56
	-10N	3.97 ± .78	3.75 ± .75	3.46 ± .63	3.50 ± .52
	0T	3.84 ± .60	3.58 ± .63	3.91 ± .73	3.50 ± .63
	0N	3.69 ± .70	3.37 ± .48	3.34 ± .78	3.12 ± .51
18 Months	-10N	3.56 ± .76	3.71 ± .46	3.04 ± .70	3.21 ± .64
	0N	3.37 ± .45	3.33 ± .67	-----	-----

a Mean + S.E., T = temperature abused, N = not temperature abused.

Table 66. Effect of final storage temperature on sensory scores for ground beef flavor intensity in ground beef patties without soy following six months storage

Final storage temperature, °F			
-10T	0T	20T	20N
4.05 ± .055a	3.80 ± .055b	2.95 ± .055d	3.22 ± .055c

abcd Means on the same line with different letters are different (P<.05)
 Mean ± S.E., T = temperature abused, N = not temperature abused.

Table 67. Effect of final storage temperature on sensory scores for ground beef flavor intensity in ground beef patties without soy following twelve months storage

Final storage temperature, °F		
-10T	0T	0N
3.83 \pm .062a	3.71 \pm .062a	3.38 \pm .062b

a Means on the same line with different letters are different ($P < .05$), Mean \pm S.E., T = temperature abused, N = not temperature abused.

Table. 68. Effect of freezing rate on sensory scores for ground beef flavor intensity in in ground beef patties without soy following nine and twelve months storage

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
9	3.83 \pm .10b	3.98 \pm .10ab	4.32 \pm .10a	3.80 \pm .10b
12 ^c	3.82 \pm .07a	3.56 \pm .07ab	3.75 \pm .07a	3.43 \pm .07b

ab Means on the same line with different letters are different ($P < .05$),
Mean \pm S.E.

c Includes both abused and nonabused product for 0°F final storage temperature.

Table 69. Effect of various storage time comparisons on sensory scores for ground beef flavor intensity in ground beef patties without soy

Evaluation time	
Immediately following freezing, 1 day	6 months
4.33 \pm .094a	3.50 \pm .094b
Immediately following freezing, 1 day	9 months
4.33 \pm .12a	3.98 \pm .12b
Immediately following freezing, 1 day	12 months ^c
4.33 \pm .12a	3.66 \pm .12b
Immediately following freezing, 1 day	12 months ^d
4.33 \pm .10a	3.64 \pm .10b
9 months	12 months
3.98 \pm .05a	3.77 \pm .05b
Immediately following freezing, 1 day	18 months ^e
4.33 \pm .12a	3.40 \pm .12b
Immediately following freezing, 1 day	18 months ^f
4.60 \pm .16a	3.49 \pm .16b
12 months	18 months
3.53 \pm .04a	3.35 \pm .04b

ab Differences between means on the same line are significant ($P < .05$),
Mean \pm S.E.

c Includes just -10°F initial storage temperature.

d Includes both temperature and nontemperature abused product for 0°F final storage temperature.

e Includes just -10°F final storage temperature.

f Includes just 0°F in 24 and 48 hr freezing rates.

Table 70. Effect of storage time (immediately following freezing, 1 day following freezing, 1 day following freezing, 1 day following freezing) on beef flavor intensity in ground beef patties without soy

6 months storage				
Immediately following freezing, 1 day	Temperature abuse	Initial storage temperature, °F =		
		-10		
		0		
4.33 ± .089a	T	Final storage temperature, °F =		
		-10		
		20		
		4.00 ± .089ab	3.91 ± .089b	2.92 ± .089c
				4.09 ± .089ab
				3.70 ± .089b
				2.97 ± .089c
	N			3.19 ± .089c
				3.25 ± .089c

abc Any mean comparison with different letters is different (P<.05), Mean ± S.E., T = temperature abused, N = not temperature abused.

Table 71. Interaction effect of storage time (six, nine months) and freezing rate on sensory scores for ground beef flavor intensity in ground beef patties without soy^a

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
6	4.23 \pm .12	3.76 \pm .12	3.77 \pm .12	3.94 \pm .12
9	3.83 \pm .12	3.98 \pm .12	4.32 \pm .12	3.80 \pm .12

^a Interaction significant ($P < .05$) by analysis of variance but not by HSD,
Mean \pm S.E.

Table 72. Effect of storage time (immediately following freezing, nine months) on sensory scores for ground beef flavor intensity in ground beef patties without soy

Immediately following freezing, 1 day	9 months storage			
	Initial storage temperature, °F =			
	-10		0	
	Final storage temperature, °F =			
	-10	0	-10	0
4.33 ± .11a	3.96 ± .11ab	3.82 ± .11b	4.19 ± .11ab	3.97 ± .11ab

ab Means on the same line with the same letters are not different ($P > .05$),
Mean ± S.E.

Table 73 . Detectable flavor scores assigned to ground beef patties without soy according to freezing rate - final storage temperature combinations following six months storage^a

Freezing rate, hrs to 0°F	Final storage temperature, °F	Detectable Flavors					
		Sour	Bitter	Metallic	Sweet	Rancid	Salty
24	-10	6.67	6.67	20.00	6.67	60.00	0.00
	0	6.25	6.25	6.25	3.13	40.63	0.00
	+20	5.56	5.56	3.33	0.00	80.00	1.11
48	-10	13.16	18.42	7.89	2.63	36.84	0.00
	0	5.56	5.56	16.67	0.00	50.00	0.00
	+20	4.49	6.74	4.49	0.00	75.28	0.00
72	-10	5.56	11.11	0.00	11.11	47.22	5.56
	0	7.89	2.63	2.63	0.00	50.00	0.00
	+20	7.00	10.00	2.00	0.00	73.00	0.00
96	-10	16.67	11.11	5.56	5.56	33.33	0.00
	0	0.00	13.04	26.09	0.00	39.13	0.00
	+20	7.79	7.79	1.30	0.00	68.83	0.00

Chi-square = 182.35, $P < .0001$.

^aValues are percentages of scores assigned within a freezing rate - final storage temperature combination.

Regardless of the freezing rate, at six months of storage under +20°F temperature, over 2/3 of the detected flavors were classified under rancid. Sour, bitter and metallic often were found to be 10-20% of the flavors for a certain treatment combination, but followed no particular trend. Also at six months, there were indications that temperature abuse reduced slightly the presence of rancid flavor (Table 74).

Rancid made up a high proportion of the detectable flavors after nine months of storage (Table 75), especially for the 0°F in 96 hour rate. Bitter was prevalent for the 0°F in 72 hour frozen patties regardless of final storage temperature and metallic was seldom ever noted for 0°F in 96 hour frozen patties. After twelve months of storage, -10°F final storage temperature produced more sour, but less rancid flavor than 0°F (Table 76). Actually, a considerable amount of rancid flavor was detected in the non-frozen patties from the various formulations prior to the study (Table 77). Just after freezing, no rancidity was detected for 0°F in 24 hour frozen product, but was over 1/3 of the flavors for the other rates. Excluding the +20°F temperature where high levels of rancid flavor were noted even after six months (and thus eliminated them), the incidence of rancidity for some rates did not increase much more until between 12 and 18 months of storage. However, for the 0°F in 96 hour frozen product, considerable increase in occurrence of rancid flavor took place between six and nine months even under -10 and 0°F storage.

Mouthcoating from mainly fat would not expect to be greatly influenced by this study unless, considerable moisture loss occurred. General data for mouthcoating is shown in Table 78. There were indications at six months of storage that mouthcoating was more prevalent in patties held at

Table 74. Detectable flavor scores assigned to ground beef patties without soy according to temperature abuse following six months storage^a

Detectable Flavors	Temperature Abuse	
	T	N
Sour	6.79	6.67
Bitter	9.13	6.06
Metallic	5.62	4.85
Sweet	1.87	0.00
Rancid	58.78	72.12
Salty	0.47	0.61
Unidentified	17.33	9.70

Chi-square = 12.58, $P < .05$.

^aValues are percentages of scores assigned within a temperature abuse category.

T = temperature abused, N = not temperature abused.

Table 75. Detectable flavor scores assigned to ground beef patties without soy according to freezing rate - final storage temperature combinations following nine months storage^a

Freezing rate, hrs to 0°F	Final storage temperature, °F	Detectable Flavors					
		Sour	Bitter	Metallic	Sweet	Kancid	Unidentified
24	-10	10.00	3.33	16.67	0.00	63.33	6.67
	0	5.58	0.00	14.71	0.00	70.59	8.82
48	-10	10.00	3.33	10.00	0.00	56.67	20.00
	0	3.57	0.00	10.71	0.00	53.57	32.14
72	-10	4.17	16.67	12.50	0.00	58.33	8.33
	0	5.26	15.79	13.16	0.00	55.26	10.53
96	-10	3.85	0.00	0.00	0.00	73.08	23.08
	0	0.00	9.68	3.23	6.45	74.19	6.45

Chi-square = 56.10, $P < .013$.

aValues are percentages of scores assigned within a freezing rate - final storage temperature combination.

Table 76 . Detectable flavor scores assigned to ground beef patties without soy according to final storage temperature following twelve months storage^a

Detectable flavors	Final Storage Temperature, °F	
	-10	0
Sour	10.84	5.28
Bitter	7.88	5.63
Metallic	10.34	10.92
Sweet	1.97	1.41
Rancid	57.14	71.13
Salty	0.49	0.00
Unidentified	11.33	5.63

Chi-square = 15.72, $P < .015$.

^aValues are percentages of scores assigned with final storage temperature categories.

Table 77. Incidence of rancid flavor in ground beef patties without soy throughout storage and according to freezing rate and final storage temperature^a

Freezing Rate, hrs to 0°F	Final Storage Temperature, °F	Before freezing	Immediately after freezing, 1 day	Evaluation Time			
				6 mo	9 mo	12 mo	18 mo
24	--	10.00	0.00				
	-10			60.00	63.33	52.00	83.87
	0			40.63	70.59	63.64	41.18
	+20			80.00	--	--	--
48	--						
	-10	35.00	42.86	36.84	56.67	65.31	63.64
	0			50.00	53.57	75.71	82.35
	+20			75.28	--	--	--
72	--						
	-10	20.00	58.82	47.22	58.33	58.33	82.86
	0			50.00	55.26	71.21	--
	+20			73.00	--	--	--
96	--						
	-10	22.22	36.36	33.33	73.08	53.57	90.63
	0			39.13	74.19	73.17	--
	+20			68.83	--	--	--

^aValues are percent occurrence of rancid flavor among all flavors within a storage time-freezing rate-final storage temperature combination.

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Before freezing		6.57 ± .65	6.41 ± .57	6.52 ± .42	6.20 ± .42
Immediately following freezing, 1 day		6.40 ± .52	6.45 ± .60	6.42 ± .51	5.93 ± .80
6 months	-10T	6.25 ± .79	6.06 ± 1.07	6.15 ± 1.07	6.02 ± .84
	0T	6.03 ± 1.02	6.11 ± 1.14	6.04 ± .98	5.87 ± .81
	20T	5.77 ± .92	5.81 ± 1.29	5.70 ± 1.08	5.64 ± 1.24
	20N	5.77 ± 1.03	5.92 ± .91	5.94 ± 1.03	6.04 ± .96
9 months	-10T	6.27 ± .88	6.06 ± .77	6.15 ± .63	6.41 ± .67
	0T	6.14 ± .89	6.05 ± .79	5.88 ± .75	6.32 ± .46
12 months	-10T	6.34 ± .48	6.14 ± .42	6.34 ± .45	6.28 ± .45
	-10N	6.34 ± .47	6.14 ± .50	6.28 ± .51	6.03 ± .46
	0T	6.25 ± .47	6.15 ± .37	6.14 ± .58	6.14 ± .44
	0N	6.25 ± .46	6.09 ± .45	6.14 ± .36	6.02 ± .47
18 months	-10N	6.21 ± .41	6.08 ± .46	6.02 ± .46	6.08 ± .52
	0N	6.21 ± .55	6.08 ± .46	-----	-----

^a Mean ± S.D., T = temperature abused, N = not temperature abused.

+20°F (Table 79). Freezing rate within a storage temperature did not greatly change the values. The 0°F in 96 hour rate at nine months did have less mouthcoating compared to 0°F in 48 and 72 hour rates (Table 80). After both nine and twelve months, patties held at -10°F were rated as having less mouthcoating than patties stored at 0°F (Table 81, 82).

Advancements in storage in comparison to just post-freezing produced more effect of mouthcoating (Table 83). For the most part, with the exception of nonabused product, storage at +20°F for six months resulted in more mouthcoating than storage at the other two temperatures or evaluation just post-freezing (Table 84). Patties frozen to 0°F in 96 hours at nine months had less mouthcoating than its counterpart at six months or the 0°F in 48 and 72 hour rates at nine months (Table 85). There were indications that for the 0°F in 48 and 72 hour rates, mouthcoating became less between just post-freezing and nine months, while the opposite was true for the 0°F in 96-hour rate (Table 86). There were signs at twelve months that 0°F final storage produced an increase in mouthcoating compared to just after freezing, while no changes occurred in patties held at -10°F (Table 87).

Generally, the slower the freezing rate, the greater the decrease in juiciness of cooked patties when evaluations occurred just post-freezing (Table 88). There were indications of a slight decrease in juiciness with advancements in storage. A substantial decrease in juiciness scores occurred for patties from the 0°F in 96-hour rate from before to just after freezing (Table 89). This reduction did not occur for the other three rates. However, following freezing, the juiciness scores of the 0°F in 96-hour frozen patties were lower only in contrast to the 0°F in 24-hour patties (Table 90). After twelve months, product from the 0°F in 48-hour

Table 79. Interaction effect of final storage temperature and rate of freezing on sensory scores for mouthcoating in ground beef patties without soy following six months

Final storage temperature, °F	Freezing rate, hours to 0°F			
	24	48	72	96
-10T	6.25 \pm .060a	6.06 \pm .060abcd	6.15 \pm .060ab	6.02 \pm .060abcde
0T	6.03 \pm .060abcd	6.11 \pm .060abc	6.04 \pm .060abcd	5.87 \pm .060bcdef
20T	5.77 \pm .060def	5.81 \pm .060cdef	5.70 \pm .060ef	5.64 \pm .060f
20N	5.77 \pm .060def	5.92 \pm .060bcdef	5.94 \pm .060abcdef	6.04 \pm .060abcd

abcdef Any mean comparison with different letters is different ($P < .05$), Mean \pm S.E.,
T = temperature abused, N = not temperature abused.

Table 80. Effect of freezing rate on sensory scores for mouthcoating in ground beef patties without soy following nine months storage

Freezing rate, hours to 0°F			
24	48	72	96
6.21 \pm .051ab	6.06 \pm .051b	6.02 \pm .051b	6.37 \pm .051a

ab Means on the same line with different letters are different ($P < .05$),
Mean \pm S.E.

Table 81. Effect of final storage temperature on sensory scores for mouthcoating in ground beef patties without soy following either nine or twelve months

Evaluation time, months	Final storage temperature, °F	
	-10	0
9	6.22 \pm .036a	6.10 \pm .036b
12 ^c	6.25 \pm .036a	6.13 \pm .036b

ab Differences between means on the same line significant ($P < .05$),
Mean \pm S.E.

^c Includes just -10°F initial storage temperature.

Table 82. Effect of final storage temperature on sensory scores for mouthcoating in ground beef patties without soy following twelve months storage

Final storage temperature, °F		
-10T	0T	.0N
6.28 \pm .037a	6.17 \pm .037ab	6.12 \pm .037b

ab Differences between means significant ($P < .05$). Mean \pm S.E.,

T = temperature abused, N = not temperature abused.

Table 83. Effect of various storage time comparisons on sensory scores for mouthcoating in ground beef patties without soy

Evaluation time	
Immediately following freezing, 1 day	6 months
6.30 \pm .047a	5.94 \pm .047b
Immediately following freezing, 1 day	9 months
6.30 \pm .060a	6.16 \pm .060b
Immediately following freezing, 1 day	18 months ^c
6.30 \pm .065c	6.11 \pm .065b
Immediately following freezing, 1 day	18 months ^d
6.42 \pm .083a	6.14 \pm .083b

ab Differences between means on the same line significant ($P < .05$),
Mean \pm S.E.

c Includes just -10°F final storage temperature.

d Includes just 0°F in 24 and 48 hr freezing rates.

Table 84. Interaction effect of storage time (immediately following freezing, six months), initial storage temperature, final storage temperature, and rate of freezing on sensory scores for mouth coating in ground beef patties without soy

Evaluation time	Initial storage temperature, °F	Freezing rate, hours to 0°F				
		24	48	72	96	
Immediately following freezing, 1 day						
6 months	-10		6.40 + .09ab	6.45 + .09a	6.42 + .09ab	5.93 + .09abcdef
		-10T	6.28 + .09abc	5.97 + .09abcdef	6.16 + .09abcde	6.11 + .09abcdef
		0T	6.03 + .09abcdef	6.14 + .09abcdef	5.97 + .09abcdef	5.89 + .09bcdef
		20T	5.72 + .09def	5.83 + .09cdef	5.72 + .09def	5.61 + .09f
	20N	5.78 + .09cdef	6.08 + .09abcdef	5.92 + .09abcdef	6.06 + .09abcdef	
	0	-10T	6.22 + .09abcd	6.14 + .09abcdef	6.14 + .09abcdef	5.93 + .09abcdef
		0T	6.03 + .09abcdef	6.08 + .09abcdef	6.11 + .09abcdef	5.86 + .09cdef
		20T	5.81 + .09cdef	5.77 + .09cdef	5.67 + .09ef	5.68 + .09ef
		20N	5.75 + .09cdef	5.75 + .09cdef	5.97 + .09abcdef	6.03 + .09abcdef

abcdef Any mean comparison with different letters is different ($P < .05$), Mean \pm S.E., T = temperature abused, N = not temperature abused.

Table 85. Interaction effect of storage time (six, nine months) and freezing rate on sensory scores for mouth coating in ground beef patties without soy

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
6	6.14 \pm .058ab	6.08 \pm .058b	6.10 \pm .058ab	5.95 \pm .058b
9	6.21 \pm .058ab	6.05 \pm .058b	6.02 \pm .058b	6.37 \pm .058a

ab Any mean comparison with the same letters is not different ($P > .05$),
Mean \pm S.E.



• 2200

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F			
			24	48	72	96
Immediately following freezing, 1 day			6.40 + .11	6.45 + .11	6.42 + .11	5.93 + .11
9 months	-10	-10	6.36 + .11	6.03 + .11	6.16 + .11	6.36 + .11
		0	6.22 + .11	6.03 + .11	5.89 + .11	6.21 + .11
	0	-10	6.19 + .11	6.09 + .11	6.14 + .11	6.46 + .11
		0	6.06 + .11	6.06 + .11	5.87 + .11	6.43 + .11

^a Interaction significant ($P < .05$) by analysis of variance, but not by HSD, Mean \pm S.E.

Table 87. Effect of storage time (immediately following freezing, 1 day following freezing, 1 day following freezing, 1 day following freezing) on scores for mouth-coating in ground beef patties without soya

12 months storage				
Immediately following freezing, 1 day	Initial storage temperature, °F =		0	
	-10		0	
	Final storage temperature, °F =		0T	
	-10	ON	-10T	ON
6.30 ± .053	6.31 ± .053	6.12 ± .053	6.14 ± .053	6.22 ± .053
			6.25 ± .053	6.10 ± .053

a Differences due to time significant ($P < .05$) by analysis of variance, but not by HSD, Mean ± S.E., T = temperature abused, N = not temperature abused.

Table 88. General table illustrating sensory scores for juiciness in ground beef patties without soy throughout storage and according to final storage temperature and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Before freezing		4.43 ± .55	4.95 ± .75	4.95 ± .58	5.00 ± .67
Immediately following freezing, 1 day		5.00 ± .74	4.75 ± .68	4.35 ± .49	3.61 ± .53
6 months	-10T	5.02 ± .71	4.61 ± .63	4.44 ± .67	4.50 ± .67
	0T	4.86 ± .53	4.44 ± .66	4.37 ± .65	4.57 ± .87
	20T	4.59 ± .47	4.21 ± .74	4.24 ± .71	4.34 ± .67
	20N	4.62 ± .62	4.68 ± .77	4.44 ± .64	4.37 ± .87
9 months	-10T	4.40 ± .63	4.41 ± .56	4.62 ± .61	4.46 ± .71
	0T	4.62 ± .81	4.83 ± .69	4.56 ± .78	4.39 ± .84
12 months	-10T	4.33 ± .64	4.22 ± .50	4.59 ± .66	4.29 ± .56
	-10N	4.78 ± .71	4.11 ± .66	4.29 ± .67	4.56 ± .57
	0T	4.34 ± .65	4.18 ± .54	4.55 ± .64	4.03 ± .57
	0N	4.80 ± .59	4.09 ± .54	4.39 ± .64	4.42 ± .54
18 months	-10N	4.31 ± .51	4.42 ± .43	4.41 ± .66	4.02 ± .70
	0N	4.40 ± .62	4.40 ± .53	-----	-----

^a Mean ± S.E., T = temperature abused, N = not temperature abused.

Table 89. Interaction effect of storage time (just before and after freezing) and freezing rate on sensory scores for juiciness in ground beef patties without soy

Evaluation time	Freezing rate, hours to 0°F			
	24	48	72	96
Before freezing	4.43 \pm .14a	4.95 \pm .14a	4.95 \pm .14a	5.00 \pm .14a
Immediately following freezing, 1 day	5.00 \pm .14a	4.75 \pm .14a	4.37 \pm .14ab	3.61 \pm .14b

ab Any mean comparison with the same letter is not different ($P > .05$),
Mean \pm S.E.

Table 90. Effect of freezing rate on sensory scores for juiciness in ground beef patties without soy following several storage periods

Evaluation time	Freezing rate, hours to 0°F			
	24	48	72	96
Immediately following freezing,				
1 day	5.00 \pm .18a	4.75 \pm .18ab	4.37 \pm .18ab	3.61 \pm .18b
12 months	4.49 \pm .08a	4.16 \pm .08b	4.51 \pm .08a	4.25 \pm .08ab

ab Means on the same line with different letters are different ($P < .05$),
Mean \pm S.E.

rate was evaluated as less juicy in comparison with the 0°F in 24 and 72 hour rates. At six months and within the temperature abused product, +20°F produced lower juiciness than -10°F final storage (Table 91). After twelve months storage, patties frozen to 0°F in 48 hours were rated as less juicy than patties frozen to 0°F in 24 hours only if they were not temperature abused (Table 92).

Additional storage (immediately following freezing vs eighteen months; nine vs twelve months) reduced juiciness scores (Table 93). Juiciness scores increased at six months for some initial-final temperature combinations for product frozen to 0°F in 96 hours (Table 94). Between six and nine months, juiciness decreased only for the 0°F in 24 hour rate (Table 95). However, at six months, patties from the 0°F in 24 hour rate were rated as higher in juiciness than all the other rates. While the 0°F in 96 hour freezing rate produced lower juiciness in patties immediately following freezing compared to the 0°F in 24 and 48 hour rates, these differences were not detected after nine months of storage (Table 96). The same situation was apparent at twelve months of storage (Table 97). Between twelve and eighteen months of frozen storage, juiciness values declined only for the 0°F in 96 hour rate (Table 98). At twelve months, patties originally frozen to 0°F in 24 hours were more juicy than those frozen to 0°F in 48 hours (Table 99). At eighteen months, these differences were not detected ($P > .05$). After eighteen months of storage, only patties from the 0°F in 24 hour rate initially stored at -10°F initially were lower in juiciness than evaluations made just post-freezing (Table 100).

Table 91. Effect of final storage temperature on sensory scores for juiciness in ground beef patties without soy following six months storage

Final storage temperature, °F			
-10T	0T	20T	20N
4.64 ± .057a	4.56 ± .057ab	4.34 ± .057b	4.53 ± .057ab

ab Means on the same line with different letters are different ($P < .05$),
 Mean ± S.E., T = temperature abused, N = not temperature abused.

Table 92. Interaction effect of temperature abuse and rate of freezing on sensory scores for juiciness in ground beef patties without soy following twelve months of storage

Temperature abuse	Freezing rate, hours to 0°F		
	24	48	96
T	4.25 ± .11ab	4.15 ± .11b	4.67 ± .11ab
N	4.78 ± .11a	4.16 ± .11b	4.39 ± .11ab

ab Any mean comparison with the same letters is not different ($P > .05$); Mean ± S.E.
 T = temperature abused, N = not temperature abused.

Table 93. Effect of various storage time comparisons on sensory scores for juiciness in ground beef patties without soy

Evaluation time	
Immediately following freezing, 1 day	18 months
4.87 \pm .14a	4.38 \pm .14b
9 months	12 months
4.54 \pm .04a	4.32 \pm .04b

ab Means on the same line with different letters are different ($P < .05$).
Mean \pm S.E.

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F		
			24	48	72
Immediately following freezing, 1 day			5.00 ± .16a	4.75 ± .16ab	4.37 ± .16abc
6 months	-10				3.61 ± .16c
		-10T	5.00 ± .16a	4.58 ± .16ab	4.42 ± .16abc
		0T	4.97 ± .16a	4.61 ± .16ab	4.53 ± .16abc
		20T	4.69 ± .16ab	4.44 ± .16abc	4.33 ± .16abc
	0	20N	4.53 ± .16abc	4.67 ± .16ab	4.22 ± .16abc
		-10T	5.03 ± .16a	4.64 ± .16ab	4.47 ± .16abc
		0T	4.75 ± .16ab	4.28 ± .16abc	4.22 ± .16abc
		20T	4.50 ± .16abc	3.97 ± .16bc	4.14 ± .16abc
	20N		4.72 ± .16ab	4.69 ± .16ab	4.67 ± .16ab
					4.28 ± .16abc

abc Any mean comparison with the same letters is not different, Mean ± S.E., T = temperature abused, N = not temperature abused.

Table 95. Interaction effect of storage time (six, nine months) and freezing rate on sensory scores for juiciness in ground beef patties without soy

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
6	4.94 ± .079a	4.53 ± .079b	4.41 ± .079b	4.54 ± .079b
9	4.51 ± .079b	4.62 ± .079ab	4.59 ± .079ab	4.43 ± .079b

ab Any mean comparison with the same letter is not different ($P > .05$),
Mean ± S.E.

Table 90.

final storage temperature and rate of freezing on sensory scores for juiciness in ground beef patties without soy

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing Rate, hours to 0°F			
			24	48	72	96
Immediately following freezing, 1 day			5.00 + .18a	4.75 + .18a	4.37 + .18ab	3.61 + .18b
9 months	-10	-10	4.38 + .18ab	4.28 + .18ab	4.62 + .18ab	4.39 + .18ab
		0	4.36 + .18ab	4.91 + .18a	4.56 + .18ab	4.46 + .18ab
	0	-10	4.42 + .18ab	4.53 + .18ab	4.61 + .18ab	4.54 + .18ab
		0	4.89 + .18a	4.75 + .18a	4.56 + .18ab	4.32 + .18ab

ab Any mean comparisons with the same letters are not different (P>.05), Mean ± S.E.

Table 37. Initial storage temperature, final storage temperature and rate of freezing on sensory scores for juiciness in ground beef patties without soy

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F				
			24	48	72	96	
Immediately following freezing, 1 day	12 months	-10					
0	-10T						

Table 98. Interaction effect of storage time (twelve, eighteen months) and rate of freezing on sensory scores for juiciness in ground beef patties without soy

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
12	4.78 \pm .10a	4.16 \pm .10bc	4.39 \pm .10abc	4.48 \pm .10ab
18	4.40 \pm .10abc	4.52 \pm .10ab	4.21 \pm .10bc	3.92 \pm .10c

abc Any mean comparison with the same letter is not different ($P > .05$),
Mean \pm S.E.

Table 99. Interaction effect of storage time (twelve, eighteen months) and freezing rate on sensory scores for juiciness in ground beef patties without soy

Evaluation time, months	Freezing rate, hours to 0°F	
	24	48
12	4.80 \pm .10a	4.09 \pm .10b
18	4.40 \pm .10ab	4.40 \pm .10ab

ab Any mean comparison with the same letters is not different ($P > .05$), Mean \pm S.E.

Table 100. Interaction effect of storage time (immediately following freezing, eighteen months), initial storage temperature, and freezing rate on sensory scores for juiciness in ground beef patties without soy

Evaluation time	Initial storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Immediately following freezing, 1 day		5.00 ± .11a	4.75 ± .11ab	4.37 ± .11abc	3.61 ± .11d
18 months	-10	4.25 ± .11bcd	4.54 ± .11abc	4.47 ± .11abc	3.92 ± .11cd
	0	4.37 ± .11abc	4.29 ± .11abcd	4.32 ± .11abcd	4.12 ± .11bcd

abcd Any mean comparison with the same letter is not different ($P < .05$),
Mean ± S.E.

Sensory scores in general format for initial tenderness are provided in Table 101. Again, as with patties with soy, there were trends for: (1) slower freezing rates to produce toughening, (2) freezing in itself to drastically reduce tenderness, and (3) slight reductions to occur in tenderness with longer storage. Before freezing, there were no differences in initial tenderness among the four different formulations (freezing rates). However, freezing reduced tenderness in all four freezing rates (Table 102). Following freezing, patties frozen to 0°F in 24 hours were evaluated as more tender than all other rates. Also patties from the 0°F in 72 hour rate were found to have higher initial tenderness than patties from the 0°F in 96 hour rate. Differences due to freezing rate (generally, that 0°F in 24 hours was more tender than other rates) was found throughout storage (Table 103). Adjusting the data for pre-freezing differences usually resulted in the patties from the 0°F in 96 hour rate then being scored as less tender than many of the other rates (Table 104). The use of +20°F storage produced lower initial tenderness after six months than -10 or 0°F (Table 105). However, these +20°F temperature values were not ($P < .05$) less than those observed just after freezing (Table 106). Less differences among the freezing rates for initial tenderness was noted following nine months storage in contrast to six months storage (Table 107). Adjusting these data for pre-freezing differences didn't alter these findings much (Table 108). While patties from the 0°F in 96 hour freezing rate were lower in tenderness than those from the 0°F in 24 hour rate just after freezing, this finding was not detected following eighteen months of storage either with or without data adjusted for pre-freezing differences (Tables 109, 110).

Table 101. General table illustrating sensory scores for initial tenderness in ground beef patties without soy throughout storage and according to final storage temperature and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Before freezing		6.14 ± .60	5.56 ± .72	5.80 ± .80	6.00 ± .58
Immediately following freezing, 1 day		5.35 ± .58	4.35 ± .75	4.75 ± .86	3.86 ± .74
6 months	-10T	5.59 ± .73	4.89 ± .68	4.40 ± .58	4.59 ± .68
	OT	5.42 ± .65	4.72 ± .69	4.15 ± .52	4.75 ± .69
	20T	4.78 ± .65	4.31 ± .47	3.85 ± .49	4.29 ± .81
	20N	4.72 ± .67	4.54 ± .66	4.21 ± .55	4.14 ± .57
9 months	-10T	5.14 ± .63	4.67 ± .53	4.59 ± .66	4.45 ± .63
	OT	5.04 ± .62	4.72 ± .63	4.51 ± .61	4.62 ± .71
12 months	-10T	5.03 ± .55	4.50 ± .51	4.84 ± .57	4.53 ± .65
	-10N	5.28 ± .68	4.64 ± .41	4.86 ± .41	4.66 ± .70
	OT	4.97 ± .66	4.72 ± .64	4.82 ± .56	4.32 ± .61
	ON	5.25 ± .49	4.57 ± .59	4.77 ± .71	4.59 ± .65
18 months	-10N	4.81 ± .44	4.87 ± .45	4.61 ± .60	4.31 ± .41
	ON	4.83 ± .46	4.77 ± .67	-----	-----

^a Mean ± S.D., T = temperature abused, N = not temperature abused.

Table 102. Interaction effect of storage time (just before and after freezing rate on sensory scores for initial tenderness in ground beef patties without soy

Evaluation time	Freezing rate, hours to 0°F		
	24	48	72
Before freezing	6.14 ± .14a	5.56 ± .14ab	5.80 ± .14ab
Immediately following freezing, 1 day	5.35 ± .14bc	4.35 ± .14de	4.75 ± .14cd
			3.86 ± .14e

abcde Any mean comparison with different letters is different ($P < .05$),
Mean ± S.E.

Table 103. Effect of freezing rate on sensory scores for initial tenderness in ground beef patties without soy following various storage periods

Storage time, months	Freezing rate, hours to 0°F			
	24	48	72	96
6	5.13 \pm .098a	4.61 \pm .098ab	4.15 \pm .098b	4.44 \pm .098b
9	5.09 \pm .095a	4.69 \pm .095ab	4.55 \pm .095b	4.54 \pm .095b
12 ^d	5.08 \pm .10a	4.61 \pm .10b	4.84 \pm .10ab	4.55 \pm .10b
12 ^e	5.08 \pm .07a	4.60 \pm .07bc	4.81 \pm .07b	4.48 \pm .07c
18 ^f	4.81 \pm .08	4.87 \pm .08	4.61 \pm .11	4.31 \pm .08

abc Means on the same line with different letters are different ($P < .05$)
Mean \pm S.E.

^d Includes only -10°F initial storage temperature.

^e Includes both temperature and nontemperature abused product stored at 0°F Final storage temperature.

^f Freezing rate effect significant ($P < .05$) by analysis of variance, but not by HSD.

Table 104. Effect of freezing rate on sensory scores for initial tenderness in ground beef patties without soy following various storage periods - data adjusted for differences prior to freezing

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
6	4.86 ± .098ab	4.93 ± .098a	4.23 ± .098b	4.32 ± .098ab
9	4.82 ± .095a	5.01 ± .095a	4.62 ± .095ab	4.41 ± .095b
12	4.82 ± .067a	4.91 ± .067a	4.89 ± .067a	4.36 ± .067b
12 ^c	4.81 ± .10ab	4.93 ± .10a	4.91 ± .10a	4.43 ± .10b
18	4.56 ± .11b	5.14 ± .11a		
18 ^d	4.55 ± .08b	5.19 ± .082a	4.68 ± .11ab	4.19 ± .082b

ab Means on the same line with different letters are different ($P < .05$).
Mean ± S.E.

c Includes just -10°F initial storage temperature.

d Includes just -10°F final storage temperature.

Table 105. Effect of final storage temperature on sensory scores for initial tenderness in ground beef patties without soy following six months storage

Final storage temperature, °F			
-10T	0T	20T	20N
4.87 ± .070a	4.76 ± .070a	4.30 ± .070b	4.40 ± .070b

ab Means on the same line with different letters are different ($P < .05$)
 Mean ± S.E., T = temperature abused, N = not temperature abused.

Table 106. Effect of storage time (immediately following freezing, six months) on sensory scores for initial tenderness in ground beef patties without soy

6 months storage					
		Initial storage temperature, °F =		0	
Immediately following freezing, 1 day	Temperature abuse	Final storage temperature, °F =			
		-10	20	-10	20
4.58 ± .10abc	T	4.92 ± .10a	4.86 ± .10a	4.82 ± .10ab	4.66 ± .10abc
	N		4.36 ± .10bc		4.44 ± .10abc

abc Any mean comparison with different letters is different ($P < .05$), Mean ± S.E., T = temperature abused, N = not temperature abused.

Table 107. Interaction effect of storage time (six, nine months), initial storage temperature and freezing rate on sensory scores for initial tenderness in ground beef patties without soy

Evaluation time months	Initial storage temperature, °F	Freezing rate, hours to 0°F		
		24	48	72
6	-10	5.59 + .13a	5.00 + .13abcd	4.39 + .13de
	0	5.42 + .13ab	4.61 + .13cde	4.17 + .13e
9	-10	5.01 + .13abcd	4.52 + .13cde	4.58 + .13cde
	0	5.17 + .13abc	4.87 + .13abcde	4.53 + .13cde

abcde Any mean comparison with different letters is different ($P < .05$)

Mean \pm S.E.

Table 108. Interaction effect of storage time (six, nine months), initial storage temperature and rate of freezing on sensory scores for initial tenderness in beef ground patties without soy - data adjusted for differences prior to freezing

Evaluation time, months	Initial storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
6	-10	5.33 + .13a	5.32 + .13a	4.46 + .13bc	4.45 + .13bc
	0	5.16 + .13ab	4.93 + .13abc	4.24 + .13c	4.64 + .13abc
9	-10	4.75 + .13abc	4.83 + .13abc	4.65 + .13abc	4.56 + .13bc
	0	4.90 + .13abc	5.19 + .13ab	4.60 + .13abc	4.27 + .13c

abc Any mean comparison with the same letters is not different ($P>.05$). Mean \pm S.E.

Table 109. Interaction effect of storage time (immediately following freezing, eighteen months), initial storage temperature, and freezing rate on sensory scores for initial tenderness in ground beef patties without soy

Evaluation time	Initial storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Immediately following freezing, 1 day		5.35 ± .16a	4.35 ± .16ab	4.75 ± .16ab	3.86 ± .16b
18 months	-10	4.87 ± .16ab	4.83 ± .16ab	4.34 ± .25ab	4.42 ± .16ab
	0	4.75 ± .16ab	4.92 ± .16ab	4.75 ± .16ab	4.21 ± .16b

ab Any mean comparisons with the same letters are not different ($P > .05$)

Mean ± S.E.

Table 110. Interaction effect of storage time (immediately following freezing, eighteen months), initial storage temperature and freezing rate on sensory scores for initial tenderness in ground beef patties without soy - data adjusted for differences prior to freezing

Evaluation time	Initial storage temperature, °F	Freezing rate, hours to 0°F		
		24	48	72
Immediately following freezing, 1 day		5.08 ± .16ab	4.66 ± .16abc	4.82 ± .16ab
18 months	-10	4.61 ± .16abc	5.15 ± .16a	4.41 ± .25abc
	0	4.48 ± .16abc	5.23 ± .16a	4.82 ± .16ab
				3.73 ± .16c
				4.29 ± .16abc
				4.08 ± .16bc

abc Any mean comparison with the same letters is not different ($P > .05$). Includes only -10°F final storage temperature.

Values for final tenderness followed a similar trend to that detected for initial tenderness (Table 111). Again, freezing reduced the tenderness substantially, especially for the slower rates of freezing. Slower rates of freezing reduced tenderness. However, some tenderization occurred with storage. Actually, patties from the 0°F in 48 hour rate did not decrease in final tenderness just as a result of freezing (Table 112). Just after freezing, the values obtained for the 0°F in 96 hour rate were less than all other rates. At twelve months of storage, patties frozen to 0°F in 24 hours were more tender than patties from both the 0°F in 48 and 96 hour rates (Table 113). At eighteen months of storage, patties frozen to 0°F in 24 hours were rated as more tender than those obtained from the 0°F in 72 and 96 hour rates. Adjusting these data for pre-freezing differences eliminated the 0°F in 24 vs 0°F in 96 hour rate differences (Table 114). However, 0°F in 48 hour patties (and sometimes 0°F in 72 hour frozen patties) were now scored as more tender than the 0°F in 24 and 96 hour frozen product. The use of +20°F final storage produced tenderness reductions over -10 and 0°F when evaluations occurred at six months (Table 115). Whereas, patties from the 0°F in 24 hour rate were found to be more tender than the other rates after nine months of storage, following twelve months of storage, only the patties from the 0°F in 48 hour rate were less tender than the 0°F in 24 hour frozen patties (Table 116).

Storage for nine, twelve or eighteen months resulted in more tender patties compared to just post-freezing (Table 117). Between twelve and eighteen months, final tenderness declined. After six months of frozen storage, the various initial-final temperature combinations produced similar tenderness to that observed just after freezing (Table 118). After

Table 111. General table illustrating patties without soy throughout storage and according to final storage temperature and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Before freezing		6.57 ± .51	5.84 ± .65	6.09 ± .43	6.30 ± .48
Immediately following freezing, 1 day		5.70 ± .59	5.15 ± .41	5.21 ± .88	4.32 ± .77
6 months	-10T	6.09 ± .61	5.36 ± .47	5.29 ± .56	5.25 ± .93
	0T	5.86 ± .53	5.31 ± .59	5.00 ± .63	5.45 ± .72
	20T	5.36 ± .64	4.94 ± .56	4.68 ± .74	4.89 ± .90
	20N	5.23 ± .63	5.12 ± .66	4.69 ± .44	4.97 ± .74
9 months	-10T	5.86 ± .57	5.58 ± .64	5.20 ± .76	5.20 ± .72
	0T	5.83 ± .65	5.47 ± .67	5.23 ± .59	5.25 ± .60
12 months	-10T	5.91 ± .54	5.35 ± .47	5.66 ± .50	5.50 ± .43
	-10N	6.00 ± .45	5.39 ± .52	5.71 ± .38	5.53 ± .56
	0T	5.77 ± .49	5.51 ± .60	5.48 ± .53	5.26 ± .57
	0N	5.95 ± .43	5.32 ± .60	5.64 ± .52	5.53 ± .65
18 months	-10N	5.69 ± .46	5.42 ± .46	5.17 ± .48	5.12 ± .42
	0N	5.62 ± .47	5.33 ± .58	-----	-----

^a Mean ± S.D., T = temperature abused, N = not temperature abused.

Table 112. Interaction effect of storage time (just before and after freezing) of freezing on sensory scores for final tenderness in ground beef patties without soy

Evaluation time	Freezing rate, hours to 0°F		
	24	48	72
Before freezing	6.57 ± .14a	5.84 ± .14bc	6.09 ± .14ab
Immediately following freezing, 1 day	5.70 ± .14bc	5.15 ± .14c	5.21 ± .14c
			4.32 ± .14d

abcd Any mean comparison with different letters is different, Mean ± S.E.

Table 113. Effect of freezing rate on sensory scores for final tenderness in ground beef patties without soy at various storage periods

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
12 ^d	5.84 ± .05a	5.39 ± .05c	5.63 ± .05ab	5.47 ± .05bc
12 ^e	5.87 ± .05a	5.39 ± .05bc	5.59 ± .05b	5.43 ± .05bc
18	5.69 ± .05a	5.42 ± .05ab	5.18 ± .07b	5.12 ± .05b

abc Means on the same line with different letters are different ($P < .05$),
Mean ± S.E.

^d Includes just -10°F initial storage temperature.

^e Includes both temperature and nontemperature abused product for 0°F final storage temperature.

Table 114. Effect of freezing rate on sensory scores for final tenderness in ground beef patties without soy following various storage periods - data adjusted for differences prior to freezing

Evaluation time	Freezing rates, hours to 0°F		
	24	48	72
Immediately following freezing, 1 day	5.33 ± .19ab	5.51 ± .19a	5.33 ± .19ab
9 months	5.48 ± .10ab	5.88 ± .10ab	5.33 ± .10ab
12 months ^c	5.47 ± .05b	5.75 ± .05a	5.74 ± .05a
12 months	5.50 ± .05b	5.75 ± .05a	5.71 ± .05a
18 months	5.29 ± .09b	5.73 ± .09a	
18 months ^d	5.32 ± .05b	5.55 ± .05a	5.29 ± .05b
			5.02 ± .05b

ab Means on the same line with different letters are different (P<.05).
Mean ± S.E.

c Includes just -10°F initial storage temperature.

d Includes just -10°F final storage temperature.

Table 115. Effect of final storage temperature on sensory scores for final tenderness in ground beef patties without soy following six months storage

Final storage temperature, °F			
-10T	0T	20T	20N
5.50 ± .070a	5.40 ± .070a	4.97 ± .070b	5.01 ± .070b

ab Means on the same line with different letters are different ($P < .05$),
 Mean ± S.E., T = temperature abused, N = not temperature abused.

Table 116. Interaction effect on storage time (nine, twelve months) and freezing rate on sensory scores for final tenderness in ground beef patties without soy

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
9	5.85 \pm .067a	5.52 \pm .067bcd	5.22 \pm .067d	5.22 \pm .067d
12	5.84 \pm .067ab	5.43 \pm .067cd	5.57 \pm .067abc	5.38 \pm .067bcd

abcd Any mean comparison with different letters is different ($P < .05$),
Mean \pm S.E.

Table 117. Effect of various storage time comparisons on sensory scores for final tenderness in ground beef patties without soy

Evaluation Time	
Immediately following freezing, 1 day	9 months
5.10 \pm .09b	5.45 \pm .09a
Immediately following freezing, 1 day	12 months ^c
5.10 \pm .07b	5.58 \pm .07a
Immediately following freezing, 1 day	12 months ^d
5.10 \pm .07b	5.57 \pm .07a
Immediately following freezing, 1 day	18 months
5.10 \pm .05b	5.35 \pm .05a
12 months	18 months
5.63 \pm .05a	5.34 \pm .07b

ab Differences between means on the same line significant ($P < .05$),
Mean \pm S.E.

c Includes just -10°F initial storage temperature.

d Includes both temperature and nontemperature abused product at 0°F final storage temperature.

Table 118. Effect of storage time (immediately following freezing, six months) on sensory scores for initial tenderness in ground beef patties without soy

		6 months storage			
		Initial storage temperature, °F =		0	
		-10			
Immediately following freezing, 1 day abuse	Temperature	Final storage temperature, °F =		20	
		-10	0	-10	0
5.10 ± .10abc	T	5.51 ± .10a	5.44 ± .10ab	4.91 ± .10c	5.48 ± .10ab
	N			5.03 ± .10abc	5.37 ± .10abc
				5.03 ± .10abc	4.98 ± .10bc

abc Any mean comparison with the same letter is not different ($P > .05$), Mean ± S.E.,
T = temperature abused, N = not temperature abused.

nine months of storage, patties initially held at -10 and finally stored at 0°F, plus those initially held at 0 and finally held at -10°F were found to be more tender than those scored just after freezing (Table 119). At both nine and twelve months, patties from the 0°F in 48 hour rate were observed to be more tender than those obtained from the 0°F in 96 hour rate.

However, the 0°F in 48 hour rate was found to receive higher tenderness scores in relation to the 0°F in 24 hour rate at nine months only (Table 120). While patties from the 0°F in 96 hour rate were rated less tender than the other rates just after freezing, there were no differences among rates at twelve months regardless of storage conditions (Table 121).

Adjusting the data for pre-freezing formulation effects on final tenderness did not alter these results (Tables 122, 123). The same situation was also noted after eighteen months of storage (Table 124), with some variations. Generally, similar tenderness at eighteen months was observed for both the 0°F in 24 and 96 hour rates.

Amount of sensory panel detected connective tissue, as would be expected, did not vary substantially according to the design of the project (Table 125). After six months of storage, patties stored at +20°F and receiving temperature abuse were found to have less connective tissue than the other final storage treatments (Table 126). There were some differences respective to freezing rate at various storage times - mainly that patties from the 0°F in 24 hour rate had less detectable connective tissue (Table 127).

Evaluations made after storage showed slightly less detectable connective tissue compared to determinations made just post-freezing (Table 128). At six months, however, evaluations from the different initial-

Table 119. Effect of storage time (immediately following freezing, nine months) on sensory scores for final tenderness in ground beef patties without soy

Immediately following freezing, 1 day	9 months storage			
	Initial storage temperature, °F =			
	-10		0	
	Final storage temperature, °F =			
	-10	0	-10	0
5.10 + .079b	5.44 ± .079ab	5.46 ± .079a	5.48 ± .079a	5.43 ± .079ab

ab Any mean comparison with the same letters is not different ($P > .05$),
Mean ± S.E.

Table 120. Interaction effect of storage time (nine, twelve months) and freezing rate on sensory scores for final tenderness in ground beef patties without soy - data adjusted for differences prior to freezing

Evaluation time, months	Freezing rates, hours to 0°F		
	24	48	72
9	5.48 + .067bc	5.88 + .067a	5.33 + .067cd
12	5.47 + .067bc	5.79 + .067ab	5.68 + .067abc
			5.28 + .067cd

abcd Any mean comparison with different letters is different ($P < .05$). Mean + S.E.

Table 121. Interaction effect of storage time (immediately following freezing, twelve months), initial storage temperature, final storage temperature, and rate of freezing on sensory scores for final tenderness in ground beef patties without soy

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F			
			24	48	72	96
Immediately following freezing, 1 day						
12 months	-10	-10T	5.70 + .13abc	5.15 + .13c	5.22 + .13c	4.32 + .13d
		0T	5.75 + .13abc	5.33 + .13abc	5.59 + .13abc	5.56 + .13abc
		ON	5.72 + .13abc	5.44 + .13abc	5.59 + .13abc	5.28 + .13bc
	0	-10T	5.91 + .13abc	5.39 + .13abc	5.61 + .13abc	5.53 + .13abc
		0T	6.06 + .13a	5.36 + .13abc	5.72 + .13abc	5.44 + .13abc
		ON	5.81 + .13abc	5.58 + .13abc	5.37 + .13abc	5.25 + .13bc
			6.00 + .13ab	5.25 + .13bc	5.68 + .13abc	5.53 + .13abc

abc Any mean comparison with the same letter is not different, Mean + S.E.,

T = temperature abused, N = not temperature abused.

Table 122. Interaction of storage time (immediately following freezing, twelve months) initial storage temperature, final storage temperature, and freezing rate on sensory scores for final tenderness in ground beef patties without soy - data adjusted for differences prior to freezing

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0° F			
			24	48	72	96
Immediately following freezing, 1 day			5.33 + .13ab	5.51 + .13ab	5.33 + .13ab	4.22 + .13c
12 months	-10	-10T	5.38 + .13ab	5.69 + .13ab	5.71 + .13ab	5.46 + .13ab
		0T	5.35 + .13ab	5.80 + .13ab	5.71 + .13ab	5.18 + .13b
		0N	5.54 + .13ab	5.75 + .13ab	5.72 + .13ab	5.43 + .13ab
	0	-10T	5.69 + .13ab	5.72 + .13ab	5.83 + .13ab	5.34 + .13ab
		0T	5.44 + .13ab	5.94 + .13a	5.49 + .13ab	5.15 + .13b
		0N	5.63 + .13ab	5.61 + .13ab	5.79 + .13ab	5.43 + .13ab

ab Any mean comparison with the same letter is not different ($P > .05$). Mean + S.E.

T = temperature abused, N = not temperature abused.

Table 123. Interaction effect of storage time (immediately following freezing, twelve months), temperature abuse, final storage temperature and freezing rate on sensory scores for final tenderness in ground beef patties without soy - data adjusted for differences prior to freezing

Evaluation time	Temperature abuse	Final storage temperature	Freezing rate, hours to 0°F			
			24	48	72	96
Immediately following freezing, 1 day 12 months	T		5.33 + .12a	5.51 + .12a	5.33 + .12a	4.22 + .12b
		-10	5.38 + .12a	5.69 + .12a	5.71 + .12a	5.46 + .12a
		0	5.35 + .12a	5.80 + .12a	5.71 + .12a	5.18 + .12a
	N		5.63 + .12a	5.75 + .12a	5.83 + .12a	5.43 + .12a
		-10	5.54 + .12a	5.75 + .12a	5.72 + .12a	5.43 + .12a
		0				

ab Any mean comparison with the same letter is not different ($P > .05$). Mean + S.E.
T = temperature abuse, N = not temperature abused. Includes only -10°F initial storage temperature.

Table 124. Interaction effect of storage time (immediately following freezing, eighteen months), initial storage temperature and freezing rate on sensory scores for final tenderness in ground beef patties without soy data adjusted for differences prior to freezing

Evaluation time	Initial storage temperature, °F	Freezing rate, hours to 0°F		
		24	48	72
Immediately after freezing, 1 day		5.33 ± .090abcd	5.51 ± .090abc	5.33 ± .090abcd
				4.22 ± .090e
18 months	-10	5.46 ± .090abcd	5.73 ± .090ab	5.04 ± .14cd
	0	5.17 ± .090bcd	5.81 ± .090a	5.50 ± .090abc
				5.15 ± .090cd
				4.90 ± .090d

abcde Any mean comparisons with different letters are different ($P < .05$). Mean ± S.E.
Includes only -10°F final storage temperature.

Table 125. General table illustrating the sensory scores for amount of connective tissue in ground beef patties without soy throughout storage and according to final storage temperature and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Temperature abuse	Freezing rate, hours to 0°F			
			24	48	72	96
Before freezing			6.43 ± .51	6.03 ± .71	6.09 ± .62	6.05 ± .68
Immediately after freezing, 1 day			6.15 ± .91	5.60 ± 1.00	5.69 ± 1.01	5.25 ± 1.10
6 months	-10	T	6.19 ± .61	5.79 ± .59	5.83 ± .60	5.86 ± .84
	0	T	6.02 ± .43	5.58 ± .84	5.71 ± .55	5.84 ± .85
	+20	T	5.82 ± .76	5.46 ± .74	5.49 ± .69	5.43 ± .81
	+20	N	5.84 ± .90	5.83 ± .95	5.68 ± .72	5.75 ± .93
9 months	-10	T	6.00 ± .52	6.06 ± .52	5.52 ± .70	5.71 ± .76
	0	T	5.99 ± .63	5.97 ± .66	5.63 ± .71	5.82 ± .77
12 months	-10	T	6.34 ± .59	5.97 ± .64	6.08 ± .51	6.18 ± .40
	0	T	6.27 ± .62	6.04 ± .53	6.05 ± .56	6.11 ± .51
	0	N	6.41 ± .41	6.00 ± .68	6.14 ± .45	6.06 ± .63
	10	N	6.37 ± .47	5.89 ± 1.02	6.18 ± .57	5.97 ± .64
18 months	-10	N	6.08 ± .41	6.06 ± .47	5.96 ± .41	5.96 ± .36
	0	N	6.12 ± .27	6.15 ± .52	-----	-----

^a Mean ± S.D., T = temperature abused, N = not temperature abused.

Table 126. Effect of final storage temperature on sensory scores for amount of connective tissue in ground beef patties without soy following six months storage

Final storage temperature, °F			
-10T	0T	20T	20N
5.92 \pm .055a	5.79 \pm .055a	5.55 \pm .055b	5.78 \pm .055a

ab Means on the same line with different letters are different ($P < .05$),
 Mean \pm S.E., T = temperature abused, N = not temperature abused.

Table 127. Effect of freezing rate on sensory scores for amount of connective tissue in ground beef patties without soy at various storage periods

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
9	5.99 ± .066a	6.02 ± .066a	5.58 ± .066b	5.77 ± .066ab
12 ^c	6.29 ± .047a	5.97 ± .047b	6.10 ± .047ab	6.11 ± .047ab
12 ^d	6.34 ± .041a	6.00 ± .041b	6.09 ± .041b	6.12 ± .041b

ab Means on the same line with the same letters are not different ($P > .05$), Mean ± S.E.

^c Includes just -10°F initial storage temperature.

^d Includes both temperature and nontemperature abused product for 0°F final storage temperature product.

Table 128. Effect of various storage time comparisons on sensory scores for amount of connective tissue in ground beef patties without soy

Evaluation time	
Before freezing	Immediately following freezing, 1 day
6.15 \pm .066a	5.67 \pm .066b
Immediately following freezing, 1 day	12 months ^c
5.67 \pm .062b	6.11 \pm .062a
Immediately following freezing, 1 day	12 months
5.67 \pm .060b	6.14 \pm .060a
Immediately following freezing, 1 day	18 months
5.67 \pm .086b	6.02 \pm .086a

ab Differences between means on the same line significant ($P < .05$), Mean \pm S.E.

c Includes just -10°F initial storage temperature.

d Includes both temperature and nontemperature abused product at 0°F final storage temperature.

final temperature combinations did not differ in connective tissue amount from product rated just after freezing (Table 129). After nine months of storage, patties from the 0°F in 72 hour rate were detected as having less connective tissue than the 0°F in 24 and 48 hour rates. These differences were not found following twelve months of storage (Table 130). In an interaction of twelve and eighteen months, at twelve months, patties from the 0°F in 48 hour rate had more detected connective tissue than the 0°F in 24 hour rate (Table 131). This difference was not found following eighteen months.

General values for Instron peak load are illustrated in Table 132. As with sensory evaluations for tenderness, freezing in itself increased Instron peak load values (reduced tenderness). Immediately following freezing, the slower the freezing rate, the higher the peak load values. Thereafter, storage time or freezing rate exerted minimal effects. The 0°F in 96 hour rate immediately post-freezing produced higher peak load values than all other rates. After nine months the 0°F in 24 hour rate product had the lowest values and this rate was significantly lower than 0°F in 72 hour rate values after eighteen months (Table 133). At six months, peak load values for patties from the 0°F in 48 hour rate were higher than the other rates if final storage was maintained at either -10 or 0°F; no differences due to rate were detected if storage was at +20°F (Table 134). Adjusting these data for pre-freezing differences removed many of these effects, except for the lower values obtained from the 0°F in 96 hour rate vs the 0°F in 48 hour rate if storage was at -10 and 0°F (Table 135). Patties from the 0°F in 24 hour rate were lower in peak load than 0°F in 48 hour rate if storage was at -10° or 0°F, but not at 0°F if no abuse was

Table 129. Effect of storage time and temperature on connective tissue in ground beef patties without soy

		6 months storage			
Immediately following freezing, 1 day	Temperature abuse	Initial storage temperature, °F =			
		-10		0	
		Final storage temperature, °F =			
		-10	20	-10	0
5.67 ± .084ab	T	6.02 ± .084a	5.79 ± .084ab	5.46 ± .084b	5.82 ± .084ab
	N			5.78 ± .084ab	5.64 ± .084ab
				5.82 ± .084ab	5.74 ± .084ab

ab Any mean comparison with the same letters is not different (P>.05), Mean ± S.E.,
T = temperature abused, N = not temperature abused.

Table 130. Interaction effect of storage time (nine, twelve months) and freezing rate on sensory scores for amount of connective tissue in ground beef patties without soy

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
9	5.99 \pm .066ab	6.02 \pm .066ab	5.58 \pm .066c	5.77 \pm .066bc
12	6.30 \pm .066a	6.01 \pm .066ab	6.06 \pm .066ab	6.15 \pm .066a

abc Any mean comparison with different letters are different ($P < .05$),
Mean \pm S.E.

Table 131. Interaction effect of storage time (twelve, eighteen months) and freezing rate on sensory scores for amount of connective tissue in ground beef patties without soy

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
12	6.34 \pm .056a	5.94 \pm .056b	6.16 \pm .056ab	6.03 \pm .056ab
18	6.08 \pm .056ab	6.06 \pm .056ab	6.09 \pm .12ab	6.12 \pm .079ab

ab Any mean comparison with the same letter is not different ($P > .05$),
Mean \pm S.E.

Table 132. General table illustrating Instron peak load values for ground beef patties without soy throughout storage and according to final storage temperature and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Before freezing		5.16 + 1.19	5.90 + 1.29	5.71 + 1.38	6.76 + 2.82
Immediately following freezing, 1 day		6.86 + 1.19	8.19 + 1.46	7.25 + 1.47	9.96 + 1.66
6 months	-10T	7.90 + 1.24	10.18 + 2.02	8.34 + 1.32	8.37 + 1.52
	0T	6.95 + 1.19	10.05 + 1.65	8.10 + 1.07	8.36 + 1.07
	20T	8.31 + 1.49	9.09 + 1.78	8.66 + 1.40	8.60 + 1.37
	20N	7.65 + 1.40	8.34 + 1.63	8.65 + 1.45	8.69 + 1.51
9 months	-10T	7.41 + 1.59	7.83 + .95	8.49 + 1.32	8.26 + 1.34
	0T	7.01 + 1.11	7.93 + 1.27	8.41 + 1.43	8.07 + 1.39
12 months	-10T	7.17 + 1.10	9.36 + 2.05	9.17 + 1.47	8.54 + 1.19
	-10N	7.35 + .83	8.28 + 1.48	8.46 + 1.26	8.76 + 1.73
	0T	6.86 + 1.17	8.78 + 1.60	9.05 + 1.48	8.96 + 1.47
	0N	7.71 + 1.21	8.08 + 1.30	8.67 + 1.32	8.86 + 1.21
18 months	-10N	6.85 + .88	8.23 + 1.58	10.16 + 1.48	9.08 + 1.43
	0N	7.28 + 1.05	8.69 + 1.18		

^a Mean + S.D. T = temperature abused, N = not temperature abused.

Table 133. Effect of freezing rate on Instron peak load values for ground beef patties without soy following various periods of storage

Evaluation time	Freezing rate, hours to 0°F			
	24	48	72	96
Immediately following freezing, 1 day	6.80 \pm .15c	8.19 \pm .15b	7.25 \pm .15bc	9.96 \pm .15a
9 months	7.21 \pm .13c	7.88 \pm .15b	8.45 \pm .13a	8.16 \pm .13ab
18 months	6.85 \pm .39b	8.23 \pm .39ab	10.16 \pm .55a	9.08 \pm .39ab

abc Means on the same line with different letters are different ($P < .05$).

Mean \pm S.E.

Table 134. Interaction effect of final storage temperature and rate of freezing on Instron peak load values for ground beef patties without soy following six months storage

Final storage temperature, °F	Freezing rate, hours to 0°F			
	24	48	72	96
-10T	7.90 \pm .29bc	10.18 \pm .29a	8.34 \pm .29bc	8.37 \pm .29bc
0T	6.95 \pm .29c	10.05 \pm .29a	8.10 \pm .29bc	8.36 \pm .29bc
20T	8.31 \pm .29bc	9.09 \pm .29ab	8.66 \pm .29ab	8.60 \pm .29ab
20N	7.65 \pm .29bc	8.34 \pm .29bc	8.66 \pm .29ab	8.69 \pm .29ab

abc Any mean comparison with the same letters is not different ($P > .05$).
Mean \pm S.E. T = temperature abused, N = not temperature abused.

Table 135. Interaction effect of final storage temperature and rate of freezing on Instron peak load values for ground beef patties without soy following six months storage - data adjusted for differences prior to freezing

Final storage temperature, °F	Freezing rate, hours to 0°F			
	24	48	72	96
-10T	8.62 + .29abcd	10.16 + .29a	8.51 + .29bcd	7.49 + .29cd
0T	7.67 + .29cd	10.03 + .29ab	8.27 + .29cd	7.48 + .29d
20T	9.04 + .29abcd	9.07 + .29abc	8.83 + .29abcd	7.73 + .29cd
20N	8.37 + .29cd	8.32 + .29cd	8.83 + .29abcd	7.82 + .29cd

abcd Any mean comparison with different letters is different ($P < .05$).
Mean + S.E. T = temperature abused, N = not temperature abused.

performed (Table 136). Data adjustment pre-freezing still produced lower peak load values after twelve months for the 0°F in 24 hour rate in contrast to the 0°F in 48 and 72 hour rates (Table 137). Also at twelve months, the 0°F in 24 hour rate patties were lower in peak load than patties from the other rates if temperature abuse occurred (Table 138). With nonabuse, the 0°F in 24 hour rate produced lower values only in relation to the 0°F in 96 hour rate. Adjusting this data for pre-freezing differences caused the 0°F in 24 and 0°F in 96 hour product to have similar values if temperature abuse occurred (Table 139).

As mentioned earlier, freezing itself reduced peak load values (Table 140). There was a slight increase in values between just after freezing and six months. While a number of the different temperature combinations were different from each other at six months of storage, none were different from values obtained just post-freezing (Table 141). A substantial decrease occurred between six and nine months storage for values obtained from 0°F in 48 hour frozen product; no reductions were noted for the other three rates (Table 142). Adjusting the data for pre-freezing differences did not affect these results (Table 143). After nine months of storage, all temperature combination treatments showed lower shear force values compared to just post-freezing if freezing was to 0°F in 96 hours (Table 144). These time effects were not noted for the other rates. Data adjustment for pre-freezing data variations did not change results (Table 145). Between nine and twelve months of storage, peak load values increased only for the 0°F in 48 hour rate product (Table 146). Also, the 0°F in 24 hour freezing rate produced lower peak load values at twelve months compared to the other rates; this was true only between 0°F

Table 136. Interaction effect of final storage temperature and rate of freezing on Instron peak load values for ground beef patties without soy following twelve months storage

Final storage temperature, °F	Freezing rate, hours to 0°F			
	24	48	72	96
-10T	7.17 ± .25c	9.36 ± .25a	9.17 ± .25a	8.54 ± .25ab
0T	6.86 ± .25c	8.78 ± .25ab	9.05 ± .25a	8.96 ± .25ab
0N	7.71 ± .25bc	8.08 ± .25abc	8.67 ± .25ab	8.86 ± .25ab

abc Any mean comparison with different letters is different ($P < .05$).

Mean ± S.E. T = temperature abused, N = not temperature abused.

Table 137. Interaction effect of final storage temperature and rate of freezing on Instron peak load values for ground beef patties without soy following twelve months storage - data adjusted for differences prior to freezing

Final storage temperature, °F	Freezing rate, hours to 0°F			
	24	48	72	96
-10T	7.89 \pm .25c	9.34 \pm .25a	9.34 \pm .25a	7.66 \pm .25c
OT	7.58 \pm .25c	8.76 \pm .25abc	9.22 \pm .25ab	8.09 \pm .25abc
ON	8.44 \pm .25abc	8.06 \pm .25abc	8.84 \pm .25abc	7.98 \pm .25bc

abc Any mean comparison with the same letters is not different ($P > .05$).
Mean \pm S.E. T = temperature abused, N = not temperature abused.

Table 138. Interaction effect of temperature abuse and rate of freezing on Instron peak load values for ground beef patties without soy following twelve months storage

Temperature abuse	Freezing rate, hours to 0°F			
	24	48	72	96
T	7.09 \pm .23d	9.20 \pm .23ab	9.31 \pm .23a	8.62 \pm .23ab
N	7.44 \pm .23cd	8.14 \pm .23bcd	8.32 \pm .23abc	8.70 \pm .23ab

abcd Any mean comparison with different letters is different ($P < .05$).

Mean \pm S.E. T = temperature abuse, N = not temperature abused. Includes just -10°F initial temperature storage.

Table 139. Interaction effect of temperature abuse and freezing rate on Instron peak load values for ground beef patties without soy following twelve months storage - data adjusted for differences prior to freezing

Temperature abuse	Freezing rate, hours to 0°F			
	24	48	72	96
T	7.81 ± .23c	9.18 ± .23ab	9.48 ± .23a	7.74 ± .23c
N	8.16 ± .23bc	8.12 ± .23bc	8.49 ± .23abc	7.83 ± .23c

abc Any mean comparison with different letters is different ($P < .05$).
Mean ± S.E. T = temperature abused, N = not temperature abused.
Includes just -10°F initial storage temperature.

Table 140. Effect of storage time on Instron peak load values for ground beef patties without soy

Evaluation time	
Before freezing	Immediately following freezing, 1 day
5.88 \pm .17b	8.06 \pm .17a
Immediately following freezing, 1 day	6 months
8.06 \pm .21b	8.51 \pm .21a

ab Differences between means significant ($P < .05$) Mean \pm S.E.

Table 141. Interaction effect of storage time (immediately following freezing, six months), initial and final storage temperature and rate of freezing on Instron peak load values for ground beef patties without soy - data adjusted for differences prior to freezing

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F			
			24	48	72	96
Immediately following freezing, 1 day						
6 months	-10		7.58 + .39de	8.17 + .39abcde	7.42 + .39de	9.08 + .39abcde
		-10T	8.26 + .39abcde	10.08 + .39abc	8.57 + .39abcde	7.98 + .39bcde
		0T	7.52 + .39de	9.59 + .39abcd	8.36 + .39abcde	7.25 + .39e
		20T	8.35 + .39abcde	8.94 + .39abcde	8.71 + .39abcde	7.64 + .39de
	0	20N	8.35 + .39abcde	8.10 + .39bcde	8.82 + .39abcde	7.97 + .39bcde
		-10T	8.99 + .39abcde	10.24 + .39ab	8.46 + .39abcde	7.01 + .39e
		0T	7.82 + .39cde	10.48 + .39a	8.18 + .39abcde	7.72 + .39de
		20T	9.73 + .39abcd	9.19 + .39abcde	8.96 + .39abcde	7.81 + .39cde
		20N	8.39 + .39abcde	8.55 + .39abcde	8.84 + .39abcd	7.67 + .39de

abcde Any mean comparison with different letters are different (P<.05). Mean + S.E. T = temperature abused, N = not temperature abused.

Table 142. Interaction effect of storage time (six, nine months) and rate of freezing on Instron peak load values for ground beef patties without soy

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
6	7.43 \pm .19cd	10.12 \pm .19a	8.22 \pm .19bc	8.36 \pm .19bc
9	7.21 \pm .19d	7.91 \pm .19bcd	8.45 \pm .19b	8.16 \pm .19bc

abcd Any mean comparison with different letters is different ($P < .05$).
Mean \pm S.E.

Table 143. Interaction effect of storage time (six, nine months) and freezing rate on Instron peak load values for ground beef patties without soy - data adjusted for differences prior to freezing

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
6	8.15 \pm .19bcd	10.10 \pm .19a	8.39 \pm .19bc	7.49 \pm .19cd
9	7.93 \pm .19bcd	7.89 \pm .23bcd	8.63 \pm .19b	7.29 \pm .19d

abcd Any mean comparison with different letters is different ($P < .05$).
Mean \pm S.E.

Table 144. Interaction effect of storage time (immediately following freezing, nine months), initial and final storage temperature and rate of freezing on Instron peak load values for ground beef patties without soy

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F			
			24	48	72	96
Immediately following freezing, 1 day			6.86 + .24e	8.19 + .24bcde	7.25 + .24bcde	9.96 + .24a
	-10	-10	7.89 + .24bcde	7.72 + .24bcde	8.38 + .24bcd	8.28 + .24bcde
		0	7.10 + .24cde	7.82 + .24bcde	8.24 + .24bcde	8.03 + .24bcde
	0	-10	6.94 + .24de	7.94 + .24bcde	8.60 + .24ab	8.24 + .24bcde
		0	6.92 + .24de	8.06 + .37bcde	8.59 + .24abc	8.11 + .24bcde

abcde Any mean comparison with different letters is different ($P < .05$). Mean + S.E.

Table 145. Interaction effect of storage time (immediately following freezing, nine months), initial and final storage temperature and rate of freezing on Instron peak load values for ground beef patties without soy - data adjusted for differences prior to freezing

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F		
			24	48	72
Immediately following freezing, 1 day					
			7.58 + .24bc	8.17 + .24abc	7.42 + .24bc
9 months	-10	-10	8.61 + .24abc	7.70 + .24abc	8.56 + .24abc
		0	7.82 + .24abc	7.80 + .24abc	8.41 + .24abc
					9.08 + .24a
	0	-10	7.67 + .24abc	7.92 + .24abc	8.78 + .24ab
		0	7.64 + .24abc	8.04 + .37abc	8.76 + .24ab
					7.36 + .24bc
					7.23 + .24c

abc Any mean comparison with the same letters is not different ($P > .05$). Mean + S.E.

1137Q, p. 16

Table 146. Interaction effect of storage time (nine, twelve months) and rate of freezing on Instron peak load values for ground beef patties without soy

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
9	7.21 \pm .19cd	8.00 \pm .24bc	8.45 \pm .19ab	8.16 \pm .19abc
12	7.01 \pm .19d	9.07 \pm .19a	9.11 \pm .19a	8.75 \pm .19ab

abcd Any mean comparison with different letters is different ($P < .05$).
Mean \pm S.E.

in 24 vs 72 hours at nine months of storage. Adjusting the data for variations pre-freezing, resulted in the 0°F in 96 hour product to be lower in peak load values than 0°F in 72 hours after nine and twelve months (Table 147). Following twelve months of storage, patties from the 0°F in 72 hour rate initially stored at -10 and finally at 0°F were the only ones to differ (higher) in peak loads from those observed just after freezing (Table 148). Correcting the data for pre-freezing differences did not change this finding (Table 149). Between twelve and eighteen months of storage, peak load values increased only for the 0°F in 72 hour rate (Table 150). Also, at eighteen months, there were more freezing rate effects than at twelve months. Data adjustment pre-freezing eliminated many of these differences (Table 151).

Information provided in Table 152 on peak loads expressed as Newtons (where thickness of cooked patty sample is considered) didn't really affect the values to any great degree when compared to peak load values in Table 132. The most dramatic effect was the higher values obtained just as a result of freezing. Before freezing, there were no differences in Newtons due to variations in formulation. However, just post-freezing, the values for the 0°F in 96 hour rate were higher than the 0°F in 72 hour rate (Table 153). This agrees closely with the results obtained for tenderness by sensory approaches. After nine months, Newton values were higher for the 0°F in 72 hour rate than all other rates. Also, the 0°F in 96 hour rate yielded higher values than the 0°F in 24 hour rate (Table 154). Adjusting these data for pre-freezing differences eliminated this last finding, but still caused 0°F in 72 hours to produce higher Newton values than other rates (Table 155). After six months, patties from the 0°F in 48 hour rate

Table 147. Interaction effect of storage time (nine, twelve months) and freezing rate on Instron peak load values for ground beef patties without soy - data adjusted for differences prior to freezing

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
9	7.93 \pm .19bc	7.98 \pm .24bc	8.63 \pm .19ab	7.29 \pm .19c
12	7.74 \pm .19bc	9.05 \pm .19a	9.28 \pm .19a	7.87 \pm .19bc

abc Any mean comparison with different letters is different ($P < .05$).
Mean \pm S.E.

Table 148. Interaction effect of storage time (immediately following freezing, twelve months), initial and final storage temperature and final storage rate of freezing on Instron peak load values for ground beef patties without soy - data adjusted for differences prior to freezing

Evaluation time	Initial storage temperature, F°	Final storage temperature, °F	Freezing rate, hours to 0°F			
			24	48	72	96
Immediately following freezing, 1 day						
12 months	-10		7.58 ± .35bc	8.17 ± .35abc	7.42 ± .35c	9.08 ± .35abc
		-10T	8.14 ± .35abc	9.51 ± .35ab	9.19 ± .35abc	7.59 ± .35bc
		OT	7.48 ± .35bc	8.86 ± .35abc	9.76 ± .35a	7.90 ± .35abc
	0	ON	8.25 ± .35abc	7.98 ± .35abc	8.35 ± .35abc	7.77 ± .35abc
		-10T	7.64 ± .35bc	9.18 ± .35abc	9.49 ± .35abc	7.74 ± .35abc
		OT	7.68 ± .35bc	8.66 ± .35abc	8.67 ± .35abc	8.27 ± .35abc
		ON	8.62 ± .35abc	8.15 ± .35abc	9.33 ± .35abc	8.19 ± .35abc

abc Any mean comparison with the same letters is not different ($P > .05$). Mean ± S.E. T = temperature abused, N = not temperature abused.

Table 149. Interaction effect of storage time (immediately following freezing, twelve months), temperature and rate of freezing on Instron peak load values for ground beef patties without soy - data adjusted for differences prior to freezing

Evaluation time	Temperature abuse	Final storage temperature, °F	Freezing rate, hours to 0°F			
			24	48	72	96
Immediately following freezing, 1 day						
12 months	T	-10	7.58 ± .33bc	8.17 ± .33abc	7.42 ± .33c	9.08 ± .33abc
		0	8.14 ± .33abc 7.48 ± .33c	9.51 ± .33ab 8.86 ± .33abc	9.19 ± .33abc 9.76 ± .33a	7.59 ± .33bc 7.90 ± .33abc
	N	-10	8.07 ± .33abc	8.26 ± .33abc	8.63 ± .33abc	7.89 ± .33abc
		0	8.25 ± .33abc	7.98 ± .33abc	8.35 ± .33abc	7.77 ± .33bc

abc Any mean comparison with the same letters are not different ($P>.05$). Mean ± S.E. T = temperature abused, N = not temperature abused. Includes just -10°F initial storage temperature.

Table 150. Interaction effect of storage time (twelve, eighteen months) and rate of freezing on Instron peak load values for ground beef patties without soy

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
12	7.44 \pm .18cd	8.14 \pm .18bcd	8.32 \pm .18bc	8.70 \pm .18b
18	7.05 \pm .18d	8.35 \pm .18bc	10.61 \pm .41a	8.98 \pm .26b

abcd Any mean comparison with different letters is not different ($P < .05$).
 Mean \pm S.E. Includes just -10°F final storage temperature.

Table 151. Interaction effect of storage time (twelve, eighteen months) and freezing rate on Instron peak load values for ground beef patties without soy - data adjusted for differences prior to freezing

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
12	8.16 + .18b	8.12 + .18b	8.49 + .18b	7.83 + .18b
18	7.77 + .18b	8.33 + .18b	10.78 + .41a	8.11 + .26b

ab Any mean comparison with the same letters is not different ($P > .05$).
Mean + S.E. Includes just - 10°F final storage temperature.

Table 152. General table illustrating Instron Newton values for ground beef patties without soy throughout storage according to final storage temperature and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Before freezing		15.52 + 3.52	17.91 + 4.06	16.77 + 4.33	19.59 + 8.93
Immediately following freezing, 1 day		25.62 + 4.80	31.90 + 5.44	25.88 + 6.01	37.87 + 6.73
6 months	-10T	33.55 + 5.86	42.59 + 8.15	35.34 + 7.44	36.77 + 6.52
	0T	28.91 + 5.40	43.22 + 8.08	35.45 + 4.37	35.17 + 4.08
	20T	35.03 + 6.86	39.18 + 7.11	37.60 + 5.76	35.79 + 5.82
	20N	32.89 + 6.00	36.22 + 7.02	38.75 + 6.01	39.85 + 6.88
9 months	-10T	27.09 + 5.95	30.01 + 4.58	34.15 + 6.13	32.12 + 5.22
	0T	27.93 + 4.12	31.05 + 5.25	35.43 + 5.74	30.44 + 5.20
12 months	-10T	28.33 + 4.11	39.32 + 6.95	40.45 + 6.60	36.35 + 5.17
	-10N	29.57 + 3.11	33.73 + 6.09	35.93 + 5.51	37.79 + 6.79
	0T	27.05 + 4.56	37.15 + 6.30	39.60 + 6.67	38.27 + 6.12
	0N	31.64 + 4.70	32.63 + 4.53	36.77 + 6.27	37.36 + 4.77
18 months	-10N	28.64 + 3.65	34.69 + 6.09	44.30 + 6.76	41.18 + 6.52
	0N	30.40 + 4.38	37.10 + 5.49	--	--

^aMean + S.D.; T = Temperature abused; N = Not temperature abused.

Table 153. Interaction effect of storage time (just before and after freezing) and rate of freezing on Instron Newton values for ground beef patties without soy

Evaluation time	Freezing rate, hours to 0°F			
	24	48	72	96
Before freezing	15.52 \pm 1.28e	17.91 \pm 1.28de	16.77 \pm 1.28e	19.59 \pm 1.28cde
Immediately following freezing, 1 day	25.62 \pm 1.28bcd	30.84 \pm 1.28ab	25.88 \pm 1.28bc	37.87 \pm 1.28a

abcde Any mean comparison with different letters is different ($P < .05$); Mean \pm S.E.

Table 154. Effect of freezing rate on Instron Newton values for ground beef patties without soy at various storage periods

Evaluation time	Freezing rate, hours to 0°F			
	24	48	72	96
Immediately before freezing	25.62 \pm .83b	31.90 \pm 1.27ab	25.88 \pm .83b	37.87 \pm .83a
9 months	27.51 \pm .76c	30.53 \pm .88bc	34.79 \pm .88a	31.28 \pm .76b

abc Means on the same line with different letters are different ($P < .05$); Mean \pm S.E.

Table 155. Effect of freezing rate on Instron Newton values for ground beef patties without soy following freezing and nine months storage - data adjusted for differences prior to freezing

Evaluation time, months	Freezing rate, hours to 0°F		
	24	48	72
Immediately following freezing, 1 day	27.54 ± 1.03b	29.89 ± 1.03ab	26.56 ± 1.03b
	35.73 ± 1.03a		
9 months	29.43 ± .75b	30.07 ± .86b	35.13 ± .75a
	29.14 ± .75b		

ab Means on the same line with different letters are different (P<.05). Mean ± S.E.

if finally stored at -10 or 0°F, but not if stored at 20°F (Table 156). Adjusting these results for differences as prior to freezing did eliminate the rate differences if storage was at -10°F (Table 157). After twelve months of storage, product from the 0°F in 24 hour freezing rate was found to be lower in Newtons than the other rates, if storage was at -10 or 0°F and temperature abuse occurred (Table 158). Product stored at 0°F and not receiving abuse did not have different Newton values than the other rates. Making pre-freezing variation adjustments to the data did cause the 0°F in 24 hour and 0°F in 96 hour values to be similar for temperature abused product stored at -10°F and 0°F (Table 159). For both temperature and nontemperature abused patties, those frozen to 0°F in 24 hours had lower Newton values than other rates (Table 160). Data adjustment for pre-freezing differences eliminated these differences for nonabused patties (Table 161). Even after eighteen months of storage, patties frozen to 0°F in 72 hours had higher Newton values than patties frozen to 0°F in 24 hours (Table 162).

Storage time comparisons of six and twelve months against just post-freezing showed Newton increases with storage (Table 163). The same was also true for eighteen months of storage (Table 164). In table 165 numerous differences at six months can be noted for Newton values. Basically all rates except 0°F in 96 hours exhibited increases in Newton values with the first six months of storage. Pre-freezing data adjustments didn't greatly affect these results (Table 166). Newton values decreased for all rates between six and nine months, but only significantly ($P < .05$) for the 0°F in 48 hour rate (Table 167). Again, altering the data for pre-freezing variations in Newtons didn't affect these results (Table 168).

ble 156. Interaction effect of final storage temperature and rate of freezing on Instron Newton values for ground beef patties without soy following six months storage

Final storage temperature, °F	Freezing rate, hours to 0°F			
	24	48	72	96
-10T	33.55 \pm 1.39cd	42.59 \pm 1.39ab	35.34 \pm 1.39bcd	36.77 \pm 1.39abc
0T	28.91 \pm 1.39d	43.22 \pm 1.39a	35.45 \pm 1.39bcd	35.17 \pm 1.39bcd
20T	35.03 \pm 1.39cd	39.18 \pm 1.39abc	37.60 \pm 1.74abc	35.79 \pm 1.39abcd
20N	32.89 \pm 1.39cd	36.22 \pm 1.39abcd	38.75 \pm 1.39abc	39.85 \pm 1.39abc

bed Any mean comparison with different letters is different ($P < .05$); Mean \pm S.E.;
T = Temperature abused; N = Not temperature abused.

Table 157. Interaction effect of final storage temperature and rate of freezing on Instron Newton values for ground beef patties without soy following six months storage - data adjusted for differences prior to freezing

Final storage temperature, °F	Freezing rate, hours to 0°F		
	24	48	72
-10T	35.48 + 1.38abcd	42.12 + 1.38ab	36.01 + 1.38abcd 34.63 + 1.38bcd
0T	30.84 + 1.38d	42.76 + 1.38a	36.13 + 1.38abcd 33.03 + 1.38cd
20T	36.96 + 1.38abcd	38.72 + 1.38abc	37.40 + 1.38abcd 33.65 + 1.38cd
20N	34.82 + 1.38bcd	35.76 + 1.38abcd	39.42 + 1.38abc 37.71 + 1.38abcd

abcd Any mean comparison with the same letters is not different ($P > .05$).
Mean + S.E. T = temperature abused; N = not temperature abused.

Table 158. Interaction effect of final storage temperature and rate of freezing on Instron Newton values for ground beef patties without soy following twelve months storage

Final storage temperature, 0°F	Freezing rate, hours to 0°F			
	24	48	72	96
-10T	28.33 \pm 1.19d	39.32 \pm 1.19a	40.45 \pm 1.19a	36.35 \pm 1.19abc
OT	27.05 \pm 1.19d	37.15 \pm 1.19abc	39.60 \pm 1.19a	38.27 \pm 1.19ab
ON	31.64 \pm 1.19cd	32.63 \pm 1.19bcd	36.77 \pm 1.19abc	37.36 \pm 1.19abc

abcd Any mean comparison with different letters is different ($P < .05$); Mean \pm S.E.;

T = Temperature abused; N = Not temperature abused.

Table 159. Interaction effect of final storage temperature and freezing rate on Instron Newton values for ground beef patties without soy following twelve months storage - data adjusted for differences prior to freezing

Final storage temperature, °F	Freezing rate, hours to 0°F		
	24	48	72
-10T	30.26 + 1.19ef	38.85 + 1.19abc	41.13 + 1.19a
0T	28.98 + 1.19f	36.69 + 1.19abcd	40.27 + 1.19ab
0N	33.57 + 1.19cdef	32.17 + 1.19def	37.45 + 1.19abcd
			35.22 + 1.19abcde

abcdef Any mean comparison with different letters is different ($P < .05$). Mean \pm S.E.
 T = temperature abused; N = not temperature abused.

Table 160. Interaction effect of temperature abuse and rate of freezing on Instron Newton values for ground beef patties without soy following twelve months storage

Temperature abuse	Freezing rate, hours to 0°F			
	24	48	72	96
T	27.77 \pm .94e	38.32 \pm .94ab	40.78 \pm .94a	36.78 \pm .94abc
N	29.84 \pm .94de	33.32 \pm .94cd	35.38 \pm .94bc	37.08 \pm .94abc

abcde Any mean comparison with different letters is different ($P < .05$); Mean \pm S.E.;
 T = Temperature abused; N = Not temperature abused. Includes just -10°F initial storage temperature.

Table 161. Interaction effect of temperature abuse and freezing rate on Instron Newton values for ground beef patties without soy following twelve months storage - data adjusted for differences prior to freezing

Temperature abuse	Freezing rate, hours to 0°F			
	24	48	72	96
T	29.70 ± .94d	37.87 ± .94ab	41.46 ± .94a	34.64 ± .94bc
N	31.76 ± .94cd	32.86 ± .94cd	36.05 ± .94bc	34.94 ± .94bc

abcd Any mean comparisons with different letters is different (P<.05).

Mean ± S.E. T = temperature abused; N = not temperature abused. Includes just -10°F initial temperature.

Table 162. Effect of freezing rate on Instron Newton values for ground beef patties without soy following eighteen months storage

Freezing rate, hours to 0°F			
24	48	72	96
28.64 \pm 1.83b	34.69 \pm 1.33ab	44.30 \pm 2.59a	41.18 \pm 1.83ab

ab Means on the same line with different letters are different ($P < .05$); Mean \pm S.E. Includes just nonabused -10°F final storage temperature product.

Table 163. Effect of various storage time comparisons on Instron Newton values for ground beef patties without soy

Evaluation time	
Immediately following freezing, 1 day	6 months
30.03 \pm 1.05b	36.65 \pm 1.05a
Immediately following freezing, 1 day	12 months ^c
30.30 \pm .96b	35.41 \pm .96a
Immediately following freezing, 1 day	12 months ^d
30.19 \pm .39b	34.91 \pm .89a

ab Differences between means on the same line are significant ($P < .05$);
Mean \pm S.E.

^cIncludes only temperature abused product for -10°F final storage temperature.

^dIncludes only -10°F initial storage temperature.

Table 164. Effect of storage time (immediately following freezing, eighteen months) on Instron Newton values for ground beef patties without soy

<u>Evaluation time</u>	
Immediately following freezing, 1 day	18 months
c = 29.93 \pm 1.39b	36.45 \pm 1.39a
d = 27.98 \pm 1.16b	32.71 \pm 1.16a

ab Difference between means on the same line is significant ($P < .05$); Mean \pm S.E.

^cIncludes just -10°F final storage temperature nonabused product.

^dIncludes just 0°F in 24 and 48 hr freezing rates.

Table 165. Interaction effect of storage time (immediately following freezing, 1 day, six months), initial storage temperature, final storage temperature and rate of freezing on Instron Newton values for ground beef patties without soy

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to °F			
			24	48	72	96
Immediately following freezing, 1 day			25.62 ± 1.87r	30.77 ± 2.73pq	25.88 ± 1.87r	37.87 ± 1.87defghijkl
6 months	-10	-10T	31.67 ± 1.87op	41.65 ± 1.87abc	34.83 ± 1.87jklmno	38.82 ± 1.87cdefgh
		0T	27.92 ± 1.87qr	41.19 ± 1.87bcd	35.69 ± 1.87ghijklm	34.63 ± 1.87klmno
		20T	31.96 ± 1.87nop	38.35 ± 1.87cdefghij	38.11 ± 1.87cdefghijkl	34.53 ± 1.87lmno
		20N	33.14 ± 1.87mnop	35.10 ± 1.87ijklmno	38.32 ± 1.87cdefghijk	40.98 ± 1.87bcde
0	0	-10T	35.44 ± 1.87hijklmn	43.52 ± 1.87ab	35.84 ± 1.87ghijklm	34.72 ± 1.87klmno
		0T	29.91 ± 1.87pq	45.26 ± 1.87a	35.21 ± 1.87hijklmno	35.71 ± 1.87ghijklm
		20T	38.10 ± 1.87cdefghijkl	40.02 ± 1.87bcdef	37.17 ± 1.87fghijkl	37.05 ± 1.87fghijkl
		20N	32.64 ± 1.87mnop	37.33 ± 1.87efghijkl	39.18 ± 1.87cdefg	38.71 ± 1.87cdefghi



Table 166. Interaction effect of storage time (immediately following freezing, six months), initial and final storage temperature and rate of freezing on Instron Newton values for ground beef patties without soy - data adjusted for differences prior to freezing

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F		
			24	48	72
Immediately following freezing, 1 day					
6 months	-10	-10T	27.54 ± 1.84o	29.89 ± 1.84mn	26.56 ± 1.84o
		0T	33.59 ± 1.84jkl	41.19 ± 1.84abc	35.51 ± 1.84ghijkl
		20T	29.84 ± 1.84no	40.73 ± 1.84bcd	36.36 ± 1.84efghi
		20N	33.88 ± 1.84ijkl	37.89 ± 1.84cdefgh	36.94 ± 1.84efghij
	0	-10T	35.07 ± 1.84hijkl	34.64 ± 1.84hijkl	38.99 ± 1.84cdefg
		0T	37.37 ± 1.84defghi	43.05 ± 1.84ab	36.51 ± 1.84efghij
		20T	31.83 ± 1.84lmn	44.80 ± 1.84a	35.89 ± 1.84fghijk
		20N	40.03 ± 1.84bcde	39.56 ± 1.84bcdef	37.85 ± 1.84cdefgh
			35.07 ± 1.84hijkl	36.87 ± 1.84efghij	39.85 ± 1.84bcde
					32.58 ± 1.84klmn
					33.57 ± 1.84jklm
					34.91 ± 1.84hijkl
					36.57 ± 1.84efghij

abcdefghijklmnopqrstuvwxyz Any mean comparison with different letters is different (P<.05). Mean ± S.E. T = temperature abused; N = not temperature abused.



Table 167. Interaction effect of storage time (six, nine months) and freezing rate on Instron Newton values for ground beef patties without soy

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
6	31.23 \pm 1.04bcd	42.91 \pm 1.04a	35.39 \pm 1.04bc	35.97 \pm 1.04b
9	27.51 \pm 1.04d	30.63 \pm 1.28cd	34.61 \pm 1.28bc	31.28 \pm 1.04bcd

abcd Any mean comparison with different letters is different ($P < .05$); Mean \pm S.E.

Table 168. Interaction effect of storage time (six, nine months), and rate of freezing on Instron Newton values for ground beef patties without soy - data adjusted for differences prior to freezing

Evaluation time, months	Freezing rate, hours to 0°F		
	24	48	72
6	33.16 ± 1.01bcd	42.44 ± 1.01a	36.07 ± 1.01b
9	29.43 ± 1.01d	30.17 ± 1.24cd	35.13 ± 1.01bc
			29.14 ± 1.01d

abcd Any mean comparisons with different letters are significant ($P < .05$). Mean ± S.E.



Most of the various temperature combinations for Newtons at nine months when compared with just post-freezing did not differ either with or without data adjustments (Table 169, 170). Between nine and twelve months, Newtons increased for all rates except 0°F in 24 hours (Table 171). Adjusting the data for pre-freezing differences did not alter these results (Table 172). Newton values after twelve months of storage were higher for the various temperature combinations compared to just post-freezing for only the 0°F in 72 hour rate (Table 173). Pre-freezing data adjustments revealed the same results (Table 174). Including temperature and nontemperature abuse combinations with these results showed similar results except that for the 0°F in 48 hour rate, temperature abused product from the -10°F final storage was higher in Newtons than those observed just after freezing (Table 175). Newton values increased between twelve and eighteen months of storage for patties frozen to 0°F in 72 hours only (Table 176) and this was the situation regardless of pre-freezing data adjustments (Table 177). For product receiving no temperature abuse and finally stored at 0°F, freezing to 0°F in 48 hours produced higher Newton values than 0°F in 24 hours (Tables 178, 179). At eighteen months, patties finally stored at 0°F regardless of initial temperature were higher in Newton values than patties evaluated just post-freezing (Table 180).

General values for Instron modulus are presented in Table 181. Modulus relates to the amount of stress in relation to strain. A high value would relate to a very rapid load in relation to time of the shear measurement. Freezing in itself created a large increase in modulus and +20°F storage also appeared to increase modulus values. There were some formulation differences for modulus pre-freezing (Table 182). Then after





Table 170. Interaction effect of storage time (immediately following freezing, nine months), initial and final storage temperature and rate of freezing on Instron Newton values for ground beef patties without soy - data adjusted for differences prior to freezing

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F			
			24	48	72	96
Immediately following freezing, 1 day						
9 months	-10	-10	27.54 + 1.51	29.89 + 1.51	26.56 + 1.51	35.73 + 1.51
			30.49 + 1.51	29.02 + 1.51	35.87 + 1.51	31.21 + 1.51
	0	0	30.08 + 1.51	34.98 + 1.51	34.98 + 1.51	27.46 + 1.51
			27.53 + 1.51	30.08 + 1.51	33.78 + 1.51	28.75 + 1.51
	0	0	29.63 + 1.51	31.15 + 1.51	35.90 + 1.51	29.13 + 1.51

a Differences significant by analyses of variance, but not by HSD. Mean ± S.E.

Table 171. Interaction effect of storage time (nine, twelve months) and freezing rate on Instron Newton values for ground beef patties without soy

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
9	-27.51 \pm .95d	-31.27 \pm 1.16cd	-34.34 \pm 1.16bc	-31.28 \pm .95cd
12	-27.69 \pm .95d	-38.23 \pm .95ab	-40.02 \pm .95a	-37.31 \pm .95ab

abcd Any mean comparison with different letters is different ($P < .05$); Mean \pm S.E.

Table 172. Interaction effect of storage time (nine, twelve months) and freezing rate on Instron Newton values for ground beef patties without soy - data adjusted for differences prior to freezing

Evaluation time, months	Freezing Rate, hours to 0°F		
	24	48	72
9	29.43 + .92d	30.80 + 1.13cd	35.13 + .92bc
12	29.62 + .92d	37.77 + .92ab	40.70 + .92a
			29.13 + .92d
			35.17 + .92bc

abcd Any mean comparison with different letters is different (P<.05). Mean + S.E.

Table 173. Interaction effect of storage time (immediately following freezing, twelve months), initial and final storage temperature on Instron Newton values for ground beef patties without soy

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to °F			
			24	48	72	96
Immediately following freezing, 1 day						
12 months	-10		25.62 ± 1.68i	31.82 ± 2.48bcdefghi	25.88 ± 1.68hi	37.87 ± 1.68abcde
		-10T	28.95 ± 1.68cdefghi	39.49 ± 1.68abc	39.31 ± 1.68abc	36.08 ± 1.68abcdefgh
		OT	26.59 ± 1.68ghi	37.17 ± 1.68abcdef	42.26 ± 1.68a	37.49 ± 1.68abcdef
		ON	30.11 ± 1.68cdefghi	32.91 ± 1.68bcdefghi	34.82 ± 1.68bcdefghi	36.37 ± 1.68abcdefg
	0	-10T	27.71 ± 1.68efghi	39.14 ± 1.68 abcd	41.60 ± 1.68ab	36.62 ± 1.68abcdefg
		OT	27.51 ± 1.68fghi	37.13 ± 1.68abcdef	36.93 ± 1.68abcdef	39.05 ± 1.68abcd
		ON	33.18 ± 1.68abcdefghi	32.35 ± 1.68bcdefghi	38.73 ± 1.68abcd	38.35 ± 1.68abcd

abcdefghi Any mean comparison with different letters is different (P<.05); Mean ± S.E.; T = Temperature abused; N = Not temperature abused.

Table 174. Interaction effect of storage time (immediately following freezing, twelve months), initial and final storage temperature and rate of freezing on Instron Newton values for ground beef patties without soy - data adjusted for differences prior to freezing

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F		
			24	48	72
Immediately following freezing, 1 day			27.54 + 1.67gh	29.89 + 1.67defgh	26.56 + 1.67h
12 months	-10	-10T	30.88 + 1.67cdefgh	39.03 + 1.67abcde	39.98 + 1.67abc
		0T	28.52 + 1.67fgh	36.71 + 1.67abcdefg	42.94 + 1.67a
		0N	32.03 + 1.67cdefgh	32.45 + 1.67bcdefgh	35.50 + 1.67abcdefgh
					35.73 + 1.67abcdefgh
	0	-10T	29.64 + 1.67defgh	38.68 + 1.67abcde	42.27 + 1.67ab
		0T	29.44 + 1.67efgh	36.67 + 1.67abcdefg	37.61 + 1.67abcdef
		0N	35.11 + 1.67abcdefgh	31.89 + 1.67cdefgh	39.40 + 1.67abcd
					34.48 + 1.67abcdefgh
					36.91 + 1.67abcdefg
					36.21 + 1.67abcdefgh

abcdefgh Any mean comparison with different letters is different (P<.05). Mean + S.E. T = temperature abused; N = not temperature abused.



Table 175. Interaction effect of storage time (immediately following freezing, twelve months), temperature abuse and rate of freezing on Instron Newton values for ground beef patties without soy - data adjusted for differences prior to freezing

Evaluation time	Temperature abuse	Final storage temperature, °F	Freezing rate, hours to 0°F			
			24	48	72	96
Immediately following freezing, 1 day			27.54 + 1.48ef	29.89 + 1.48def	26.56 + 1.48f	35.73 + 1.48abcde
12 months	T	-10	30.88 + 1.48cdef	39.02 + 1.48abc	39.98 + 1.48ab	33.94 + 1.48bcdef
		0	28.52 + 1.48def	36.71 + 1.48abcd	42.94 + 1.48a	35.35 + 1.48abcde
	N	-10	31.50 + 1.48bcdef	33.27 + 1.48bcdef	36.60 + 1.48abcd	35.65 + 1.48abcde
		0	32.03 + 1.48bcdef	32.45 + 1.48bcdef	35.50 + 1.48abcde	34.23 + 1.48bcdef

abcdef Any mean comparison with different letters is different ($P < 0.05$). Mean + S.E. T = temperature abused; N = not temperature abused. Includes just -10°F initial storage temperature.



Table 176. Interaction effect of storage time (twelve, eighteen months) and freezing rate on Instron Newton values for ground beef patties without soy

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
12	29.84 \pm 1.03de	33.32 \pm 1.03cde	35.38 \pm 1.03bcd	37.08 \pm 1.03bc
18	29.12 \pm 1.03e	35.95 \pm 1.03bcd	45.43 \pm 2.30a	41.52 \pm 1.4 ab

abcde Any mean comparison with different letters is different ($P < .05$); Mean \pm S.E.
Includes just -10°F final storage temperature.



Table 177. Interaction effect of storage time (twelve, eighteen months) and freezing rate on Instron Newton values for ground beef patties without soy - data adjusted for differences prior to freezing

Evaluation time, months	Freezing rate, hours to 0°F		
	24	48	72
12	31.76 ± 1.03c	32.86 ± 1.03c	36.05 ± 1.03bc
18	31.04 ± 1.03c	35.38 ± 1.03bc	46.10 ± 2.30a
			34.94 ± 1.03bc
			39.38 ± 1.46b

abc Any mean comparison with different letters is different ($P < .05$). Mean ± S.E.
Includes just -10°F final storage temperature.



Table 178. Interaction effect of storage time (twelve, eighteen months) and freezing rate on Instron Newton values for ground beef patties without soy

Evaluation time, months	Freezing rate, hours to 0°F	
	24	48
12	31.64 + .94b	32.63 + .94ab
18	30.40 + .94b	37.10 + .94a

ab Any mean comparison with the same letters is not different ($P > .05$); Mean + S.E.

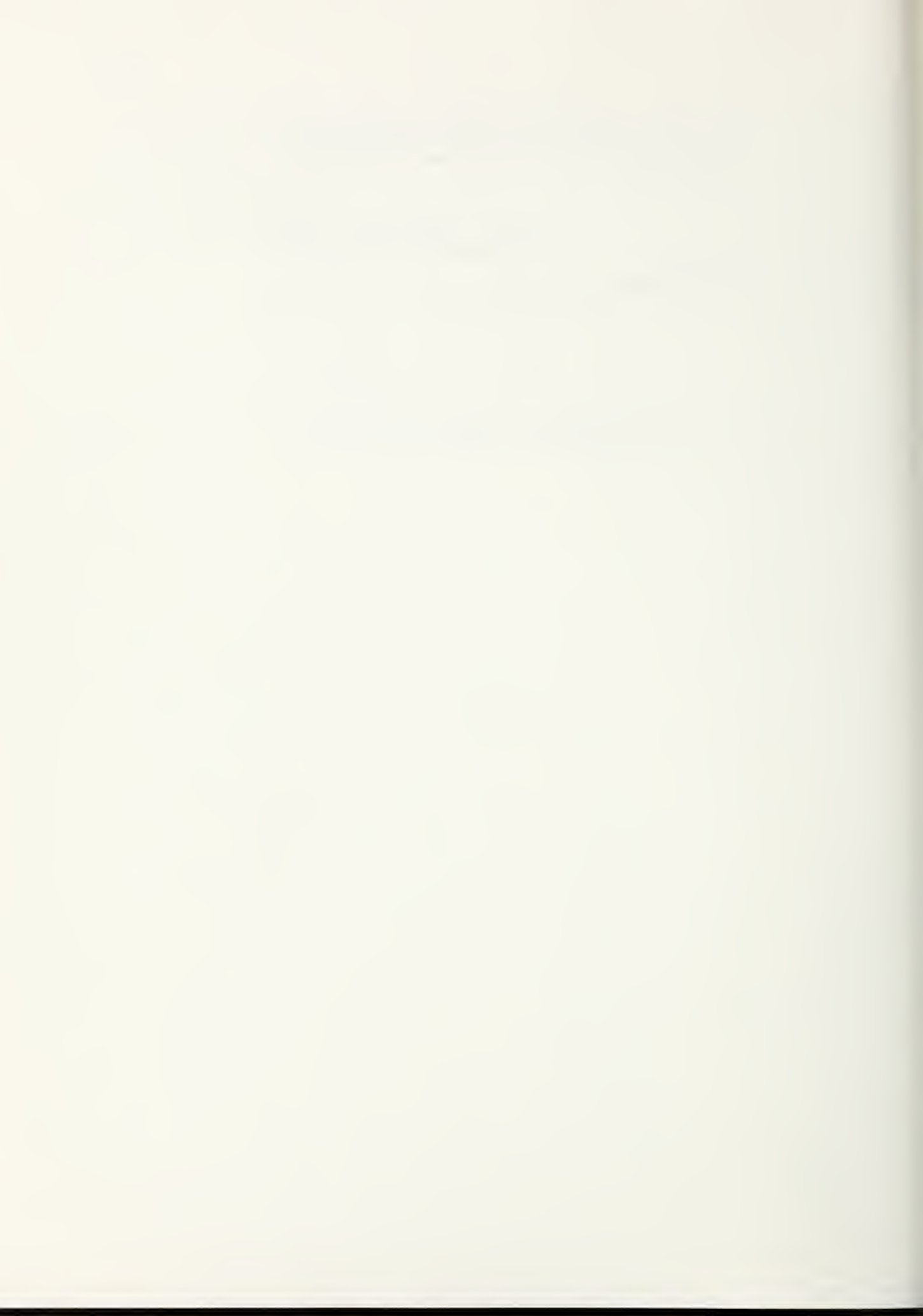


Table 179. Interaction effect of storage time (twelve, eighteen months) and freezing rate on Instron Newton values for ground beef patties without soy - data adjusted for differences prior to freezing^a

Evaluation time, months	Freezing rate, hours to 0°F	
	24	48
12	33.57 \pm .94	32.17 \pm .94
18	32.33 \pm .94	36.64 \pm .94

^a Differences significant ($P < .05$) by analysis of variance, but not by HSD. Mean \pm S.E. Includes any 0°F final storage temperature and non-temperature abused product.

Table 180. Effect of storage time (immediately following freezing, eighteen months) on Instron Newton values for ground beef patties without soy

		18 months storage	
Immediately following freezing, 1 day	Initial Storage temperature, °F =	-10	0
	Final Storage temperature, °F =	-10	-10
		31.27 ± 1.04ab	33.69 ± 1.04a
		32.06 ± 1.04ab	33.81 ± 1.04a
		27.98 ± 1.04b	

ab Means on the same line with the same letters are not different ($P > .05$); Mean ± S.E. Includes just 0°F in 24 and 48 hr freezing rates.



Table 181. General table illustrating Instron modulus values for ground beef patties without soy throughout storage and according to final storage temperature and rate of freezing - no statistical analysis^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Before freezing		25.72 ± 5.62	21.09 ± 3.66	20.75 ± 3.41	23.63 ± 3.83
Immediately following freezing, 1 day		31.13 ± 4.49	33.57 ± 5.38	27.68 ± 5.62	32.97 ± 4.80
6 months	-10T	35.20 ± 4.54	38.14 ± 4.87	36.84 ± 5.41	38.92 ± 6.20
	0T	32.41 ± 4.23	40.33 ± 6.38	40.12 ± 3.98	40.70 ± 6.13
	20T	39.71 ± 5.50	42.30 ± 5.67	42.93 ± 5.88	40.69 ± 7.85
	20N	40.41 ± 4.61	42.59 ± 4.28	41.89 ± 4.89	42.74 ± 4.15
9 months	-10T	38.07 ± 6.56	36.97 ± 4.16	36.67 ± 6.20	35.62 ± 6.30
	0T	38.35 ± 5.41	35.11 ± 4.86	39.09 ± 4.99	34.69 ± 5.35
12 months	-10T	36.08 ± 4.45	37.61 ± 4.76	39.82 ± 4.27	43.61 ± 5.02
	-10N	37.29 ± 4.46	42.55 ± 5.04	41.76 ± 5.74	44.44 ± 4.58
	0T	37.24 ± 4.35	38.86 ± 5.16	38.15 ± 4.24	41.85 ± 6.24
	0N	39.40 ± 5.76	41.35 ± 5.96	42.33 ± 5.64	43.52 ± 4.99
18 months	-10N	36.21 ± 5.76	37.26 ± 4.19	41.62 ± 5.61	42.80 ± 5.79
	0N	38.69 ± 5.21	35.70 ± 4.15	--	--

^amean ± S.D.; T = Temperature abused; N = Not temperature abused.



Table 182. Effect of freezing rate at various storage times on Instron modulus values for ground beef patties without soy

Evaluation time	Freezing rate, hours to 0°F			
	24	48	72	96
Immediately before freezing	25.72 \pm .26a	21.09 \pm .26c	20.75 \pm .26c	23.63 \pm .26b
12 months ^d	38.24 \pm .66b	39.27 \pm .66b	40.10 \pm .66b	42.99 \pm .66a
12 months ^e	32.08 \pm .71b	39.61 \pm .71b	39.88 \pm .71b	43.28 \pm .71a

abc Means on the same line with different letters are different ($P < .05$);
mean \pm S.E.

^dIncludes just -10°F initial storage temperature.

^eIncludes -10°F and 0°F final storage temperature and temperature abused product. Includes 0°F final storage temperature nonabused product.



twelve months, patties frozen to 0°F in 96 hours had higher values. Adjusting or standardizing the data for pre-freezing variation in modulus caused more differences in modulus as a function of freezing rate (Table 183). Now, 0°F in 24 hour patties had lower modulus values than 0°F in 72 hour patties at nine months, all rates at twelve months and 0°F in 48 hour product following eighteen months. After six months of frozen storage, patties initially and finally stored at 0°F had lower values than many of the other initial-final temperature combinations (Table 184). Adjusting the data for the variation pre-freezing didn't affect this finding, but did cause the patties from the 0°F final storage, initially held at -10°F to also be lower in modulus than most treatments (Table 185). Temperature abuse produced lower modulus values for patties stored initially at 0°F than nonabuse when measurements were taken at twelve months - these differences were not associated with -10°F storage (Table 186).

Storage time comparisons against just post-freezing showed increases in modulus values (Table 187). After six months of storage for the 0°F in 24 hour rate, only the +20°F final storage produced higher values; the same being true for 0°F in 48 hours if product was initially stored at 0°F. All of the initial-final temperature combinations for 0°F in 72 hours increased over just post-freezing in modulus, while mainly the patties stored initially at -10°F increased in modulus for patties frozen to 0°F in 96 hours (Table 188). Adjusting these data for pre-freezing differences caused many of the values for patties stored at +20°F to exceed those found just post-freezing regardless of rate (Table 189). Modulus values between six and nine months increased only for patties from the 0°F in 96 hour rate (Table 190). While patties from the 0°F in 24 hour rate had lower modulus



Table 183. Effect of freezing rate on Instron modulus values for ground beef patties without soy following various periods of storage - data adjusted for differences prior to freezing

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
9	35.29 \pm .85b	37.75 \pm .98ab	39.92 \pm .85a	34.32 \pm .85b
12 ^c	35.16 \pm .71b	41.32 \pm .71a	41.93 \pm .71a	42.45 \pm .71a
12 ^d	35.32 \pm .66b	40.98 \pm .66a	42.15 \pm .66a	42.16 \pm .66a
18 ^e	34.53 \pm .99b	38.19 \pm .99a		

ab Means on the same line with different letters are different ($P < .05$).
Mean \pm S.E.

^c Includes just -10°F initial storage temperature.

^d Includes just 0°F in initial storage temperature and -10°F initial storage temperature for temperature abused roasts.

^e Includes just non-temperature abused roasts.

Table 184. Interaction effect of initial and final storage temperature and freezing rate on Instron modulus values for ground beef patties without soy following six months storage

Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
-10	-10T	35.82 + 1.39bcde	37.33 + 1.39abcde	37.45 + 1.39abcde	42.23 + 1.39abc
	0T	32.74 + 1.39de	39.46 + 1.39abcde	41.06 + 1.39abcd	39.70 + 1.39abcde
	20T	40.73 + 1.39abcd	41.70 + 1.39abc	40.75 + 1.39abcd	42.20 + 1.39abc
	20N	39.70 + 1.39abcde	42.06 + 1.39abc	43.05 + 1.39ab	42.41 + 1.39abc
0	-10T	34.58 + 1.39cde	38.94 + 1.39abcde	40.23 + 1.39abcde	35.62 + 1.39bcde
	0T	32.07 + 1.39e	41.17 + 1.39abc	39.19 + 1.39abcde	41.69 + 1.39abc
	20T	38.69 + 1.39abcde	42.91 + 1.39abc	45.12 + 1.39a	39.17 + 1.39abcde
	20N	41.12 + 1.39abca	43.12 + 1.39ab	40.73 + 1.39abcd	43.06 + 1.39ab

abcde Any mean comparison with different letters is different ($P < .05$). Mean ± S.E. T = temperature abused, N = not temperature abused.

Table 185. Interaction effect of initial storage temperature, final storage temperature, and rate of freezing on Instron modulus values for ground beef patties without soy following six months storage-data adjusted for differences prior to freezing

Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F		
		24	48	72
-10	-10T	32.90 + 1.39efgh	39.04 + 1.39abcdef	39.50 + 1.39abcdef
	0T	29.82 + 1.39gh	41.19 + 1.39abcde	43.11 + 1.39abcd
	20T	37.80 + 1.39bcdefg	43.40 + 1.39abc	42.79 + 1.39abcd
	20N	36.78 + 1.39bcdefgh	43.77 + 1.39abc	45.10 + 1.39ab
0	-10T	31.66 + 1.39fgh	40.65 + 1.39abcde	42.28 + 1.39abcd
	0T	29.15 + 1.39h	42.88 + 1.39abcd	41.23 + 1.39abcde
	20T	35.77 + 1.39cdefgh	44.62 + 1.39ab	47.16 + 1.39a
	20N	38.20 + 1.39bcdefg	44.83 + 1.39ab	42.78 + 1.39abcd

abcdefgh Any mean comparison with different letters is different (P<.05). Mean + S.E. T = temperature abused; N = not temperature abused.



Table 186. Interaction effect of initial storage temperature and final storage temperature on Instron modulus values for ground beef patties without soy following twelve months storage

Initial storage temperature, °F	Final storage temperature, °F		
	-10T	0T	0N
-10	40.33 \pm .80ab	39.04 \pm .80b	39.98 \pm .80ab
0	39.23 \pm .80b	39.01 \pm .80b	43.31 \pm .80a

ab Any mean comparison with the same letters is not different ($P > .05$). Mean \pm S.E.

T = temperature abused, N = not temperature abused.

Table 187. Effect of various storage time comparisons on Instron modulus values for ground beef patties without soy

Evaluation times	
Immediately before freezing	Immediately following freezing, 1 day
22.80 \pm .85b	31.34 \pm .85a
Immediately following freezing, 1 day	6 months
31.34 \pm .79b	39.87 \pm .79a
Immediately following freezing, 1 day	9 months
31.34 \pm 1.11b	36.84 \pm 1.11a
Immediately following freezing, 1 day	12 months ^c
31.34 \pm .93b	40.21 \pm .93a
Immediately following freezing, 1 day	12 months
31.34 \pm .92b	40.15 \pm .92a
Immediately following freezing, 1 day	18 months ^d
31.34 \pm 1.25b	39.62 \pm 1.25a
Immediately following freezing, 1 day	18 months ^e
32.35 \pm 1.62b	36.96 \pm 1.62a

ab Difference between means on the same line are significant ($P < .05$);
Mean \pm S.E.

^cIncludes just -10°F initial storage temperature.

^dIncludes just nonabused product.

^eIncludes just 0°F in 24 and 48 hr freezing rates.



Table 188. Interaction effect of storage time (immediately following freezing, six months), initial storage temperature, final storage temperature and rate of freezing on Instron modulus values for ground beef patties without soy

Evaluation time	Initial storage Temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F			
			24	48	72	96
Immediately following freezing, 1 day			31.13 ± 1.50fg	33.58 ± 1.50cdefg	27.68 ± 1.50g	32.97 ± 1.50defg
6 months	-10	-10	35.82 ± 1.50bcdefg	37.33 ± 1.50abcdef	37.45 ± 1.50abcder	42.23 ± 1.50abc
		0	32.74 ± 1.50defg	39.48 ± 1.50abcdef	41.06 ± 1.50abcde	39.70 ± 1.50abcder
		20T	40.73 ± 1.50abcde	41.70 ± 1.50abca	40.75 ± 1.50abcde	42.21 ± 1.50abc
		20N	39.70 ± 1.50abcdef	42.06 ± 1.50abc	43.05 ± 1.50ab	42.41 ± 1.50auc
	0	-10	34.58 ± 1.50bcdefg	38.94 ± 1.50abcdef	40.23 ± 1.50abcde	35.52 ± 1.50bcdefg
		0	32.07 ± 1.50efg	41.17 ± 1.50abcd	39.19 ± 1.50abcdef	41.69 ± 1.50abcd
		20T	38.69 ± 1.50abcdef	42.91 ± 1.50ab	45.12 ± 1.50a	39.17 ± 1.50abcder
		20N	41.12 ± 1.50abcd	43.12 ± 1.50ab	40.73 ± 1.50abcde	43.06 ± 1.50ab

abcdefg Any mean comparison with different letters is different ($P < .05$). mean ± S.E. T = temperature abuse, N = not temperature abused.



Table 189. Interaction effect of storage time (immediately following freezing, six months) initial and final storage temperature and rate of freezing on Instron modulus values for ground beef patties without soy - data adjusted for differences prior to freezing

Evaluation time	Initial storage temperature °F	Final storage temperature °F	Freezing rate, hours to 0°F			
			24	48	72	96
Immediately following freezing, 1 day						
6 months	-10	-10T	28.21 + 1.50j	35.28 + 1.50defghij	29.72 + 1.50hij	32.13 + 1.50fghij
		OT	32.90 + 1.50efghij	39.04 + 1.50abcdefg	39.50 + 1.50abcdefg	41.39 + 1.50abcde
		20T	29.82 + 1.50hij	41.19 + 1.50abcde	43.11 + 1.50abcd	38.87 + 1.50abcdefg
		20N	37.80 + 1.50bcdefghi	43.40 + 1.50abcd	42.79 + 1.50abcd	41.37 + 1.50abcde
	0	-10T	36.78 + 1.50bcdefghi	43.77 + 1.50abcd	45.10 + 1.50ab	41.57 + 1.50abcde
		OT	31.66 + 1.50ghij	40.65 + 1.50abcdefg	42.28 + 1.50abcd	34.79 + 1.50defghij
		20T	29.15 + 1.50ij	42.88 + 1.50abcd	41.23 + 1.50abcde	40.85 + 1.50abcdef
		20N	35.77 + 1.50cdefghij	44.62 + 1.50abc	47.16 + 1.50a	38.33 + 1.50abcdefgh
			38.20 + 1.50abcdefgh	44.83 + 1.50ab	42.78 + 1.50abcd	42.23 + 1.50abcd

abcdefghij Any mean comparison with different letters is different (P<.05). Mean + S.E. T = temperature abused; N = not temperature abused.

Table 190. Interaction effect of storage time (six, nine months) and freezing rate on Instron modulus values for ground beef patties without soy

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
6	33.81 \pm .92c	39.23 \pm .92ab	39.48 \pm .92ab	39.81 \pm .92a
9	38.21 \pm .92abc	36.12 \pm 1.13abc	37.88 \pm .92abc	35.15 \pm .92bc

abc Any mean comparison with different letters is different ($P < .05$);
Mean \pm S.E.

values than the other rates following six months, no differences were noted after nine months. Data adjustment to these data resulted in the values for the 0°F in 72 hour rate at nine months to be higher than the 0°F in 24 and 96 hour rates (Table 191). Following nine months of storage, all the initial-final temperature combinations, except for -10°F initial and 0°F final produced higher modulus values than those recorded just after freezing (Table 192). Between nine and twelve months, modulus increased only for the 0°F in 96 hour rate (Table 193). Data adjustment for pre-freezing differences did not change these results (Table 194). Between twelve and eighteen months of storage, Instron modulus values decreased for the 0°F in 48 hour rate (Table 195), even with pre-freezing data adjustment (Table 196).

General values for Instron fail energy are given in Table 197. The values are at 80% of the total energy. As with other Instron values, freezing produced an increase in fail energy values. Values tended to be erratic and didn't follow a trend respective to temperature or time. At six months, the 0°F in 24 hour rate produced lower values than the other rates, while at nine months, this was true only between the 0°F in 24 hour rate and the 0°F in 48 and 72 hours (Table 198). After eighteen months, values for the 0°F in 24 hour rate were lower only in comparison with the 0°F in 96 hour rate. Data adjustments for differences prior to freezing showed no rate effects of six months for fail energy. Nine and eighteen month differences also changed (Table 199). At nine months, patties frozen to 0°F in 96 hours had lower fail energy values than the other rates. After eighteen months, product from the 0°F in 96 hour rate had lower values than 0°F in 72 hour rate. Freezing rate and temperature abuse,

Table 191. Interaction effect of storage time (six, nine months) and rate of freezing on Instron modulus values for ground beef patties without soy - data adjusted for differences prior to freezing

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
6	30.88 \pm .92d	40.94 \pm .92a	41.53 \pm .92a	38.98 \pm .92ab
9	35.29 \pm .92bc	37.83 \pm 1.13abc	39.92 \pm .92a	34.32 \pm .92cd

abcd Any mean comparison with different letters is different ($P < .05$).

Mean \pm S.E.

Table 192. Effect of storage time (immediately following freezing, nine months) on Instron modulus values for ground beef patties without soy

		9 months storage	
Immediately following freezing, 1 day	Initial Storage temperature, °F =	-10	0
	Final Storage temperature, °F =	0	-10
31.34 ± .99b		36.62 ± .99a	35.67 ± .99ab
		37.04 ± .99a	37.75 ± 1.14a

ab Any mean comparisons with different letters are different ($P < .05$); Mean ± S.E.

Table 193. Interaction effect of storage time (nine, twelve months) and rate of freezing on Instron modulus values for ground beef patties without soy

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
9	38.21 \pm .73bc	35.68 \pm .89bc	37.88 \pm .73bc	35.15 \pm .73c
12	37.66 \pm .73bc	38.23 \pm .73bc	38.98 \pm .73b	42.73 \pm .73a

abc Any mean comparison with different letters is different ($P < .05$);
Mean \pm S.E.

Table 194. Interaction effect of storage time (nine, twelve months) and freezing rate on Instron modulus values for ground beef patties without soy - data adjusted for differences prior to freezing

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
9	35.29 \pm .73c	37.38 \pm .89bc	39.92 \pm .73ab	34.32 \pm .73c
12	34.74 \pm .73c	39.94 \pm .73ab	41.03 \pm .73a	41.89 \pm .73a

abc Any mean comparison with different letters is different ($P < .05$).
Mean \pm S.E.



Table 195. Interaction effect of storage time (twelve, eighteen) months) and rate of freezing on Instron modulus values from ground beef patties without soy

Evaluation time, months	Freezing rate, hours to 0°F	
	24	48
12	39.40 \pm .66ab	41.35 \pm .66a
18	38.69 \pm .66ab	35.70 \pm .66b

ab Any mean comparison with different letters is different ($P < .05$). Mean \pm S.E.

Table 196. Interaction effect of storage time (twelve, eighteen months) and rate of freezing on Instron modulus values for ground beef patties without soy - data adjusted for differences prior to freezing

Evaluation time, months	Freezing rate, hours to 0°F	
	24	48
12	36.48 \pm .66b	43.05 \pm .66a
18	35.77 \pm .66b	37.41 \pm .66b

ab Any mean comparison with the same letters is not different (P<.05). Mean \pm S.E.

Table 197. General table illustrating Instron fail energy values for ground beef patties without soy throughout storage and according to final storage temperature and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Before freezing		4.93 ± 1.15	5.80 ± 1.23	5.47 ± 1.11	7.05 ± 3.05
Immediately following freezing, 1 day		6.43 ± 1.10	7.27 ± 1.49	6.28 ± 1.25	7.53 ± 1.31
6 months	-10T	6.81 ± 1.18	8.57 ± 1.09	7.47 ± 1.13	7.31 ± 1.35
	0T	6.42 ± 1.35	8.25 ± 1.62	7.25 ± 1.09	7.70 ± 1.29
	20T	7.18 ± 1.25	8.07 ± 1.52	7.83 ± 1.47	7.86 ± 1.40
	20N	7.12 ± 1.38	7.77 ± 1.54	7.64 ± 1.56	7.68 ± 1.49
9 months	-10T	6.96 ± 1.55	7.95 ± 1.19	7.53 ± 1.26	8.04 ± 1.30
	0T	6.83 ± 1.26	8.28 ± 1.46	7.59 ± 1.36	8.18 ± 1.27
12 months	-10T	7.00 ± 1.18	8.52 ± 2.00	7.70 ± 1.47	7.47 ± 1.03
	-10N	7.08 ± .98	8.02 ± 1.59	7.49 ± 1.32	7.66 ± 1.43
	0T	6.39 ± 1.46	7.99 ± 1.47	7.53 ± 1.40	7.87 ± 1.22
	0N	7.12 ± 1.25	7.97 ± 1.42	7.69 ± 1.30	8.04 ± 1.28
18 months	-10N	6.38 ± .93	7.63 ± 1.57	8.63 ± 1.36	7.75 ± 1.40
	0N	6.88 ± 1.02	7.78 ± 1.27	--	--

^aMean ± S.D.; T = Temperature abused; N = Not temperature abused.

Table 198. Effect of freezing rate on Instron fail energy values for ground beef patties without soy following various storage periods

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
6	6.88 \pm .14c	8.17 \pm .14a	7.55 \pm .14b	7.64 \pm .14ab
9	6.89 \pm .18b	8.11 \pm .20a	7.56 \pm .18ab	8.11 \pm .18a
18 ^C	6.38 \pm .25b	7.63 \pm .25ab	8.63 \pm .36ab	7.76 \pm .25a

ab Means on the same line with different letters are different ($P < .05$);
Mean \pm S.E.

^CIncludes just nontemperature abused, -10°F final storage temperature product.

Table 199. Effect of freezing rate on Instron fail energy values for ground beef patties without soy at various storage periods - data adjusted for differences prior to freezing

Evaluation time, months	Freezing rates, hours to 0°F		
	24	48	96
6	7.77 + .14a	8.18 + .14a	7.89 + .14a
9	7.78 + .18a	8.12 + .20a	7.90 + .18a
18 ^c	7.26 + .25ab	7.64 + .25ab	8.97 + .36a
			6.40 + .14a
			6.88 + .18b
			6.52 + .25b

ab Means on the same line with different letters are different ($P > .05$). Mean \pm S.E.

c Includes only -10°F final storage temperature.

while involved in a significant ($P < .05$) interaction, followed no apparent trend (Table 200) after twelve months storage. Pre-freezing data adjustments resulted in most 0°F in 96 hour treatment combinations being lower in fail energy values than the other rates (Table 201), regardless of temperature abuse. Also, at twelve months, patties initially and finally stored at 0°F were higher in fail energy if no temperature abuse was applied (Table 202).

Freezing in itself and storage time comparisons with just post-freezing produced increases in fail energy values (Table 203). At twelve months, most of those increases seemed associated with the 0°F in 48 hour rate and 0°F final storage for the 0°F in 72 hour rate (Table 204). Between twelve and eighteen months, fail energy increased for the 0°F in 72 hour rate (Table 205). Making adjustments for pre-freezing differences did not change these results (Table 206).

The next section of the report deals with weight loss during various stages of the study including cooking. General values for weight loss associated with freezing through cooking are depicted in Table 207. These total project losses indicate a rate effect (more with slower freezing rates) at about every storage temperature-storage time combination. After six months, total loss through cooking was higher for the 0°F in 72 and 96 hour rates vs the 0°F in 24 and 48 hour rates (Table 208). Following twelve months, regardless of the final storage temperature, 0°F in 96 hour patties always had higher total losses than 0°F in 24 hour patties (Table 209).

The first six months produced a decrease in total weight loss while between six and nine months, an increase occurred (Table 210). However,

1. The first part of the document discusses the importance of maintaining accurate records of all transactions and activities. It emphasizes that this is essential for ensuring transparency and accountability in the organization's operations.

2. The second part outlines the various methods and tools used to collect and analyze data. It mentions the use of surveys, interviews, and focus groups to gather information from stakeholders. Additionally, it discusses the application of statistical software to process and interpret the collected data.

3. The third part describes the results of the data analysis. It highlights the key findings and trends identified during the study. These findings are presented in a clear and concise manner, using tables and graphs to illustrate the data where appropriate.

4. The fourth part discusses the implications of the findings for the organization. It explains how the results can be used to inform decision-making and to develop strategies for improving performance and achieving the organization's goals.

5. The fifth part provides a summary of the document and offers conclusions based on the findings. It reiterates the importance of ongoing monitoring and evaluation to ensure that the organization remains effective and responsive to its environment.

Table 200. Interaction effect of temperature abuse, final storage temperature and rate of freezing on Instron fail energy values for ground beef patties without soy following twelve months storage

Temperature abuse	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
T	-10	7.31 + .20bc	8.69 + .20a	7.38 + .20bc	7.57 + .20abc
	0	6.46 + .20c	8.11 + .20ab	7.94 + .20ab	8.04 + .20ab
N	-10	7.08 + .20bc	8.02 + .20ab	7.49 + .20bc	7.65 + .20ab
	0	7.17 + .20bc	7.97 + .20ab	7.34 + .20bc	7.72 + .20ab

abc Any mean comparison with different letters is different ($P < .05$). Mean ± S.E.
 T = temperature abused, N = not temperature abused.



Table 201. Interaction effect of temperature abuse, final storage temperature and freezing rate on Instron fail energy values for ground beef patties without soy following twelve months storage - data adjusted for differences prior to freezing

Temperature abuse	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
T	-10	8.19 + .20ab	8.71 + .20a	7.72 + .20abc	6.34 + .20d
	0	7.34 + .20bcd	8.13 + .20ab	8.28 + .20ab	6.81 + .20cd
N	-10	7.97 + .20abc	8.03 + .20ab	7.83 + .20abc	6.42 + .20d
	0	8.06 + .20ab	7.98 + .20abc	7.68 + .20abc	6.49 + .20d

abcd Any mean comparison with different letters is different ($P < .05$). Mean + S.E.
T = temperature abused, N = not temperature abused. Includes just -10°F initial storage temperature.

Table 202. Interaction effect of initial storage temperature and rate of freezing on Instron fail energy values for ground beef patties without soy following twelve months storage

Initial storage temperature, °F	Final storage temperature, °F		
	-10T	0T	0N
-10	7.74 \pm .11ab	7.64 \pm .11ab	7.55 \pm .11ab
0	7.61 \pm .11ab	7.26 \pm .11b	7.86 \pm .11a

ab Any mean comparison with the same letters is not different ($P > .05$). Mean \pm S.E.

T = temperature abused, N = not temperature abused.

Table 203. Effect of various storage time comparisons on Instron fail energy values for ground beef patties without soy

Evaluation times	
Immediately before freezing	Immediately following freezing, 1 day
5.81 ± .15b	6.88 ± .15a
Immediately following freezing, 1 day	6 months
6.88 ± .20b	7.55 ± .20a
Immediately following freezing, 1 day	9 months
6.88 ± .18b	7.68 ± .18a
Immediately following freezing, 1 day	12 months ^c
6.88 ± .13b	7.61 ± .13a
Immediately following freezing, 1 day	12 months ^d
6.88 ± .13b	7.62 ± .13a
Immediately following freezing, 1 day	18 months ^e
6.88 ± .24b	7.76 ± .24a

ab Differences between means on the same line are significant ($P < .05$);
Mean ± S.E.

^cIncludes just temperature abused product for -10°F final storage temperature.

^dIncludes just -10°F initial storage temperature.

^eIncludes just -10°F final storage temperature.

Table 204. Interaction effect of storage time (immediately following freezing, twelve months), initial and final storage temperature and rate of freezing on Instron fail energy values for ground beef patties without soy

Evaluation time	Initial storage Temperature, °F	Final storage temperature, °F	Freezing Rate, hours to 0°F			
			24	43	72	96
Immediately following freezing, 1 day			6.43 ± .25ef	7.27 ± .25abcdef	6.28 ± .25f	7.53 ± .25abcdef
12 months	-10	-10T	7.31 ± .25abcdef	8.70 ± .25a	7.38 ± .25abcdef	7.57 ± .25abcdef
		OT	6.46 ± .25def	8.11 ± .25abc	7.94 ± .25abcd	8.04 ± .25abc
		ON	7.17 ± .25bcdef	7.97 ± .25abc	7.33 ± .25abcdef	7.72 ± .25abcdef
	0	-10T	6.69 ± .25cdef	8.35 ± .25ab	8.01 ± .25abc	7.37 ± .25abcdef
		OT	6.33 ± .25f	7.86 ± .25abcde	7.13 ± .25bcdef	7.71 ± .25abcdef
		ON	7.07 ± .25bcdef	7.97 ± .25abc	8.03 ± .25abc	8.37 ± .25ab

abcdef Any mean comparison with different letters is different ($P < .05$). Mean ± S.E. T = temperature abuse, N = not temperature abused.



Table 205. Interaction effect of storage time (twelve, eighteen months) on Instron fail energy values for ground beef patties without soy

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
12	7.13 \pm .15bc	8.00 \pm .15b	7.41 \pm .15bc	7.69 \pm .15b
18	6.64 \pm .15c	7.52 \pm .15bc	9.21 \pm .33a	7.65 \pm .21b

abc Any mean comparison with different letters is different ($P < .05$);
Mean \pm S.E. Includes just -10°F final storage temperature.

Table 206. Interaction effect of storage time (twelve, eighteen months) and rate of freezing on Instron fail energy values for ground beef patties without soy - data adjusted for differences prior to freezing

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
12	8.01 + .15b	8.01 + .15b	7.76 + .15b	6.45 + .14c
18	7.53 ± .15b	7.53 ± .15b	9.55 ± .33a	6.42 ± .21c

abc Any mean comparison with different letters is different ($P < .05$).
Mean ± S.E. Includes just -10°F final storage temperature.

Table 207. General table illustrating the percent change in weight from just before freezing until after cooking for ground beef patties without soy throughout storage and according to final storage temperature and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Immediately following freezing, 1 day					
6 months		-40.60 + .33	-41.99 + 1.81	-42.46 + .55	-43.80 + .10
	-10T	-40.06 + .27	-40.54 + 1.16	-42.23 + .37	-43.14 + .76
	0T	-40.07 + .96	-41.11 + 1.5	-42.06 + .22	-40.95 + .69
	20T	-41.24 + 1.27	-40.59 + .89	-42.27 + .85	-42.52 + .78
	20N	-40.77 + .79	-41.39 + .40	-42.19 + .51	-42.79 + .84
9 months	-10T	-40.13 + 1.42	-42.43 + 1.3	-42.26 + 1.55	-43.37 + .80
	0T	-40.23 + 1.17	-41.42 + 1.15	-41.92 + .97	-43.10 + .75
12 months	-10T	-41.36 + .89	-41.85 + 1.1	-42.23 + .75	-43.56 + .34
	-10N	-40.12 + .99	-41.74 + .27	-42.85 + 1.63	-43.89 + .51
	0T	-40.65 + .43	-41.26 + .36	-42.18 + .96	-41.87 + 1.18
	0N	-39.85 + .99	-41.71 + 1.09	-42.10 + 1.22	-43.84 + .50
18 months	-10N	-40.04 + 1.04	-41.19 + .45	-41.59 + .96	-43.00 + .85
	0N	-39.51 + .16	-40.42 + 1.41	--	--

^aMean ± S.E.; T = Temperature abused; N = Not temperature abused.

Table 208. Effect of freezing rate on percent change in weight of ground beef patties without soy from just before freezing until after cooking for patties stored six months

Freezing rate, hours to 0°F			
24	48	72	96
-40.54 ± .22b	-40.78 ± .22b	-42.19 ± .22a	-42.35 ± .22a

ab Means on the same line with different letters are different ($P < .05$); Mean ± S.E.

Table 209. Interaction effect of final storage temperature and rate of freezing on percent change in weight from just before freezing until after cooking for ground beef patties without soy stored twelve months

Final storage temperature	Freezing rate, hours to 0°F			
	24	48	72	96
-10T	41.36 \pm .35cd	41.85 \pm .35bc	42.23 \pm .35abc	43.56 \pm .35ab
OT	40.65 \pm .35cd	41.26 \pm .35cd	42.18 \pm .35abc	41.87 \pm .35bc
ON	39.45 \pm .35d	41.71 \pm .35c	42.1 \pm .35abc	43.84 \pm .35a

abcd Any mean comparison with different letters is different ($P < .05$);
Mean \pm S.E.; T = Temperature abused, N = Not temperature abused.

Table 210. Effects of various storage time comparisons on percent change in weight of ground beef patties without soy from just before freezing until after cooking

Evaluation times	
Immediately following freezing, 1 day	6 months
-42.21 \pm .34a	-41.41 \pm .34b
6 months	9 months
-41.21 \pm .20b	-41.84 \pm .21a
12 months ^C	18 months ^C
-40.78 \pm .20a	-39.97 \pm .20b

ab Means on the same line with different letters are different ($P < .05$);
Mean \pm S.E.

^CIncludes only 0°F final storage temperature.

total loss decreased between twelve and eighteen months. After six months, there were indications that +20°F final storage produced more total loss (Table 211).

Values for loss just due to freezing did not show much difference due to freezing rate (Table 212). General values from just before freezing until after storage are given next. There was a trend for more loss in this category as related to slower freezing rates (Table 213). Thus, it would appear that perhaps much of the effect of freezing rate on weight loss is not so much measured in freezing, but rather in storage. Slower freezing rates produced more weight loss than faster rates after twelve months, with these effects more evident for the nonabused product (Table 214). At eighteen months, patties from the 0°F in 48 hour rate had more loss due to freezing and storage than patties from the 0°F in 24 hour rate if initial storage was at -10°F; initial storage at 0°F produced the opposite results (Table 215).

Weight loss during storage was quite variable respective to freezing rate and storage temperature (Table 216). At twelve months, patties frozen to 0°F in 24 and 48 hours had less weight loss during storage than patties frozen to 0°F in 72 hours (Table 217). At eighteen months of storage, product from the 0°F in 48 hour rate, but not the 0°F in 24 hour rate, if stored at -10°F initially had more loss during storage than if stored at 0°F (Table 218).

Cooking loss increased, even after storage, with slower rates of freezing (Table 219). It is surprising that freezing rate exerts its effects on an attribute like cooking loss, even after storage. The 0°F in 72 and 96 hour rates yielded higher cooking losses than the 0°F in 24 and

Table 211. Effect of storage time (immediately following freezing, six months) on percent change in weight of ground beef patties without soy from just before freezing until after cooking^a

Immediately following freezing, 1 day	Temperature abuse	6 months storage			
		Initial Storage temperature, °F =	Final Storage temperature, °F =		
		-10	0	-10	0
42.21 ± .32	T	-41.38 ± .32	-41.0 ± .32	-41.80 ± .32	-41.61 ± .32
	N	--	--	-41.58 ± .32	--
					-41.52 ± .32
					-42.00 ± .32

^aDifferences due to storage time significant ($P < .05$) by analysis of variance, but not by HSD; Mean ± S.E.; T = Temperature abused; N = Not temperature abused.



Table 212. General table illustrating the percent change in weight of ground beef patties without soy from just before freezing until just after freezing throughout storage and according to final storage temperature and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Immediately following freezing, 1 day					
6 months	-10T	-.72 ± .07	-.79 ± .36	-.70 ± .25	-.78 ± .01
	0T	-.66 ± .13	-.64 ± .31	-.58 ± .25	-.69 ± .057
	20T	-.60 ± .19	-.66 ± .13	-.63 ± .08	-.63 ± .27
	20N	-.70 ± .18	-.60 ± .22	-.69 ± .07	-.74 ± .40
9 months	-10T	-.66 ± .18	-.63 ± .12	-.65 ± .12	-.61 ± .24
	0T	-.54 ± .13	-.62 ± .15	-.55 ± .36	-.88 ± .11
		-.73 ± .23	-.60 ± .11	-.75 ± .43	-.58 ± .17
	-10T	-.73 ± .16	-.65 ± .042	-.65 ± .13	-.62 ± .091
12 months	-10N	-.53 ± .39	-.74 ± .018	-1.18 ± .72	-.59 ± .0086
	0T	-.64 ± .12	-.63 ± .05	-.89 ± .51	-.64 ± .13
	0N	-.49 ± .34	-.63 ± .13	-.60 ± .37	-.64 ± .11
	-10N	-.68 ± .19	-.87 ± .21	-.83 ± .36	-.60 ± .086
18 months	0N	-.70 ± .18	-.62 ± .16	--	--

^aMean ± S.D.; T = Temperature abused; N = Not temperature abused.

Table 213. General table illustrating the percent change in weight of ground beef patties without soy from just before freezing until after storage throughout storage and according to final storage temperature and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
6 months	-10T	-0.87 + .26	-0.89 + .41	-1.20 + .59	-0.95 + .19
	0T	-0.88 + .30	-0.85 + .15	-1.21 + 1.09	-1.17 + .20
	20T	-1.13 + .36	-1.21 + .45	-1.20 + .08	-1.32 + .41
	20N	-1.03 + .17	-1.15 + .41	-1.56 + .70	-1.71 + .43
9 months	-10T	-0.80 + .30	-0.85 + .50	-1.79 + 1.38	-1.34 + .27
	0T	-1.15 + .64	-1.18 + .52	-1.29 + .48	-1.47 + .81
12 months	-10T	-0.99 + .35	-1.27 + .34	-1.22 + .43	-1.29 + .20
	-10N	-0.72 + .08	-1.06 + .39	-3.07 + .35	-0.86 + .83
	0T	-1.08 + .50	-0.84 + .68	-1.65 + .87	-1.12 + .05
	0N	-0.86 + .08	-1.11 + .70	-2.15 + .98	-1.36 + .96
18 months	-10N	-1.70 + .48	-1.29 + .32	-1.79 + .33	-0.83 + .36
	0N	-1.56 + .39	-2.20 + 1.44	--	--

^aMean ± S.D.; T = Temperature abused; N = Not temperature abused.



Table 214. Interaction effect of temperature abuse and rate of freezing on percent change in weight of ground beef patties without soy from just before freezing until after twelve months storage

Temperature abuse	Freezing rate, hours to 0°F			
	24	48	72	96
T	-0.85 + .29c	-1.14 + .29bc	-1.45 ± .29b	-1.45 ± .29b
N	-0.82 ± .29c	-1.33 ± .29b	-2.91 ± .29a	-1.17 ± .29bc

abc Any mean comparison with different letters is different ($P < .05$);
Mean ± S.E.; T = Temperature abused, N = Not temperature abused.



Table 215. Interaction effect of initial storage temperature and rate of freezing on percent change in weight of ground beef patties without soy from just before freezing until after 18 months storage^a

Initial storage temperature	Freezing rate, hours to 0°F	
	24	48
-10	-1.57 \pm .29	-2.42 \pm .29
0	-1.70 \pm .29	-1.08 \pm .29

^aInteraction effect significant ($P < .05$) by analysis of variance but not by HSD.
Mean \pm S.E.

Table 216. General table illustrating the percent change in weight of ground beef patties without soy from just after freezing until after storage throughout storage and according to final storage temperature and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F				
		24	48	72	96	
6 months	-10T	-.22 + .16	-.45 + .35	-.63 + .42	-.27 + .15	
	OT	-.28 + .22	-.19 + .18	-.58 + 1.14	-.54 + .17	
	20T	-.43 + .29	-.61 + .27	-.51 + .05	-.58 + .21	
	20N	-.37 + .27	-.52 + .34	-.91 + .83	-1.11 + .47	
9 months	-10T	-.25 + .19	-.23 + .06	-1.12 + 1.09	-.47 + .19	
	OT	-.42 + .43	-.58 + .56	-.53 + .66	-.90 + .72	
12 months	-10T	-1.71 + 2.82	-.63 + .37	-.58 + .54	-.67 + .2	
	-10N	-.19 + .31	-.33 + .38	-1.91 + 1.07	-.27 + .06	
	OT	-.44 + .40	-.21 + .71	-.77 + .66	-.48 + .83	
	ON	-.37 + .33	-.49 + .62	-1.56 + .89	-.73 + .89	
18 months	-10N	-1.03 + .46	-.42 + .41	-.98 + .50	-.75 + .32	
	ON	.86 + .41	-1.6 + 1.43	--	--	

^aMean + S.D.; T = Temperature abused; N = Not temperature abused.

Table 217. Effect of freezing rate on percent change in weight of ground beef patties without soy from just after freezing until after twelve months storage

Freezing rate, hours to 0°F			
24	48	72	96
$-.26 \pm .21b$	$-.58 \pm .21b$	$-1.46 \pm .21a$	$-.65 \pm .21ab$

ab Means on the same line with different letters are different ($P < .05$); Mean \pm S.E. Includes only -10°F initial storage temperature product.

Table 218. Interaction effect of initial storage temperature and rate of freezing on percent change in weight of ground beef patties without soy from just after freezing until after 18 months storage^a

Initial storage temperature	Freezing rate, hours to 0°F	
	24	48
-10	$-.89 \pm .27ab$	$-1.74 \pm .27a$
0	$-1.01 \pm .27ab$	$-.28 \pm .27b$

ab Any mean comparison with the same letter is not different ($P > .05$); Mean \pm S.E.



Table 219. General table illustrating the percent cooking loss for ground beef patties without soy throughout storage and according to final storage temperature and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Before freezing		38.29 ± 1.32	38.18 ± 2.44	39.83 ± 1.95	35.6 ± .71
Immediately following freezing, 1 day		40.97 ± .36	42.5 ± 1.63	43.06 ± .70	44.26 ± .10
6 months	-10T	40.23 ± .35	40.29 ± .71	42.3 ± .31	43.48 ± .81
	OT	40.31 ± 1.01	41.4 ± 1.48	42.16 ± .47	41.31 ± .63
	20T	41.28 ± 1.31	40.7 ± 1.04	42.31 ± .90	42.69 ± .76
	20N	41.07 ± .96	41.43 ± .26	42.08 ± .15	42.7 ± .67
9 months	-10T	40.38 ± 1.38	42.65 ± 1.22	42.39 ± 1.04	43.45 ± .90
	OT	40.29 ± 1.14	41.53 ± 1.23	42.15 ± 1.01	42.96 ± .84
12 months	-10T	41.25 ± 1.10	41.8 ± 1.14	42.17 ± .88	43.69 ± .40
	-10N	40.31 ± 1.09	41.8 ± .30	41.8 ± 1.94	44.3 ± .54
	OT	40.76 ± .33	41.27 ± .63	41.93 ± .75	41.92 ± .97
	ON	40.10 ± .97	41.76 ± 1.17	41.57 ± 1.28	43.77 ± .48
18 months	-10N	39.67 ± 1.11	40.85 ± .72	41.17 ± 1.04	42.73 ± .76
	ON	39.16 ± .50	39.61 ± 1.56	--	--

^aMean ± S.D.; T = Temperature abused; N = Not temperature abused.



48 hour rates after six months (Table 220). For nonabused -10°F final storage product after eighteen months, 0°F in 96 hour freezing rate produced higher cooking losses than the 0°F in 24 hour rate. More loss during cooking was found for -10°F final storage vs 0°F final storage following twelve months storage (Table 221). Freezing in itself increased cooking loss as did storage in comparison with just post-freezing (Table 222). Cooking loss decreased between twelve and eighteen months. Following six months of storage, patties initially stored at -10°F and 0°F finally were lower in cooking loss than patties evaluated just after freezing (Table 223). After twelve months, patties initially stored at 0 and finally at -10°F had lower cooking losses than patties just post-freezing (Table 224). There were indications that 0°F final storage following eighteen months produced more cooking loss than that noted just after freezing (Table 225).

The next set of tables depicts changes in patty thickness as a result of cooking. Freezing in itself produced an increase in thickness (Table 226) with storage up to six months causing greater declines in thickness. Before freezing, patties from the formulations selected for the 0°F in 24 and 72 hour rates had more swelling than patties from the 0°F in 48 and 96 hour rates (Table 227). At eighteen months, patties from the 0°F in 96 hour rate underwent more shrink than the 0°F in 72 hour rate. After six months of storage, $+20^{\circ}\text{F}$ storage of nonabused patties created more shrink in patty thickness than the other final storage temperatures (Table 228). Following twelve months of storage, patties from the 0°F in 24 hour rate, temperature abused and stored finally at either -10 or 0°F had less shrink than the other rates (Table 229). Nonabused product from the 0°F in

Table 220. Effect of freezing rate on percent cooking loss in ground beef patties without soy at six and eighteen months of storage

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
6	40.72 \pm .22b	40.95 \pm .22b	42.21 \pm .22a	42.54 \pm .22a
18 ^c	39.67 \pm .30b	40.85 \pm .30ab	41.17 \pm .43ab	42.73 \pm .30a

ab Means on the same line with the same letters are not different ($P > .05$);
Mean \pm S.E.

^cIncludes just nonabused -10°F final stored product.



Table 221. Effect of final storage temperature on percent cooking loss of ground beef patties without soy following twelve months storage

Final storage temperature, °F		
-10T	0T	0N
42.23 \pm .20a	41.47 \pm .20ab	41.80 \pm .20b

ab Means on the same line with the same letters are not different ($P>.05$);
 Mean \pm S.E.; T = Temperature abused;
 N = Not temperature abused.

Table 222. Effects of various storage time comparisons on percent cooking loss in ground beef patties without soy

Evaluation times	
Immediately before freezing	Immediately following freezing, 1 day
37.97 \pm .49b	42.70 \pm .49a
Immediately following freezing, 1 day	6 months
42.70 \pm .33a	41.43 \pm .33b
Immediately following freezing, 1 day	12 months
42.70 \pm .34a	41.85 \pm .34b
Immediately following freezing, 1 day	18 months ^c
41.74 \pm .74a	39.82 \pm .74b
Immediately following freezing, 1 day	18 months ^d
42.70 \pm .30a	41.10 \pm .30b
12 months	18 months
42.06 \pm .19a	40.83 \pm .19b

ab Means on the same line with different letters are different ($P < .05$);
Mean \pm S.E.

^cIncludes just 0°F in 24 and 48 hr freezing rates.

^dIncludes just 0°F and -10°F final storage temperatures.

Table 223. Effect of storage time (immediately following freezing, six months) on percent cooking loss of ground beef patties without soy

		6 months storage					
Immediately after freezing, 1 day	Temperature abuse	Initial Storage temperature, °F =		Final Storage temperature, °F =		U	
		-1U	U	-1U	+2U	-1U	+2U
42.70 ± .31a	T	41.34 ± .31ab	41.14 ± .31b	41.83 ± .31a	41.80 ± .31ab	41.45 ± .31ab	41.66 ± .31ab
	N	--	--	41.61 ± .31ab	--	--	42.03 ± .31ab

ab Any mean comparisons with the same letters are not different ($P > .05$); Mean ± S.E.; T = Temperature abused; N = Not temperature abused.

Table 224. Effect of storage time (immediately following freezing, twelve months) on percent cooking loss of ground beef patties without soy

		12 months storage			
Immediately following freezing, 1 day	Temperature abuse	Initial Storage temperature, °F =		-10	
		Final Storage temperature, °F =		-10	
	T	42.22 ± .31ab	41.70 ± .31ab	42.24 ± .31ab	41.23 ± .31b
	N	--	42.07 ± .31ab	--	41.52 ± .31ab
42.70 ± .31a					0

ab Any mean comparisons with the same letters are not different ($P > .05$); Mean ± S.E.; T = Temperature abused;
N = Not temperature abused.

Table 225. Effect of storage time (immediately following freezing, eighteen months) on percent cooking loss of ground beef patties without soy^a

		18 months storage		
Immediately following freezing, 1 day	Initial Storage temperature, °F =	-10		0
	Final Storage temperature, °F =	-10	0	-10
41.74 ± .61		40.24 ± .60	39.38 ± .60	40.28 ± .60
				39.40 ± .60

^aStorage effect significant ($P < .05$) by analyses of variance, but not by HSD; Mean ± S.E.



Table 226. General table illustrating the percent change in patty thickness during cooking for ground beef patties without soy through storage and according to final storage temperature and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Before freezing		+38.93 + 18.05	+23.49 + 12.99	+42.71 + 15.50	+24.57 + 15.44
Immediately following freezing, 1 day		- 7.92 + 7.59	- 8.02 + 8.11	+ .16 + 13.24	-12.07 + 6.49
6 months	-10T	-19.05 + 6.42	-15.73 + 6.66	-15.61 + 10.32	-20.77 + 6.12
	OT	-18.58 + 7.16	-18.23 + 5.61	-17.24 + 6.77	-18.18 + 6.96
	20T	-19.61 + 6.31	-19.77 + 6.38	-17.76 + 7.36	-19.02 + 6.30
	20N	-20.18 + 6.04	-20.21 + 5.79	-21.55 + 6.73	-25.76 + 6.56
9 months	-10T	+ .77 + 10.25	- 5.05 + 8.97	-10.67 + 10.12	- 9.36 + 7.71
	OT	- 7.45 + 9.01	-10.78 + 10.72	-14.90 + 6.23	-11.00 + 6.27
12 months	-10T	- 8.14 + 6.45	-19.30 + 6.13	-18.78 + 8.70	-18.81 + 5.85
	-10N	-10.54 + 8.68	-8.22 + 9.00	-16.35 + 8.03	-21.56 + 5.23
	OT	- 8.90 + 6.55	-21.09 + 5.76	-20.53 + 7.03	-18.75 + 9.20
	ON	-12.36 + 7.71	-10.87 + 8.38	-14.99 + 8.47	-17.01 + 6.39
18 months	-10N	-14.66 + 7.13	-17.37 + 6.55	-19.43 + 9.50	-23.76 + 6.71
	ON	-14.59 + 8.48	-18.87 + 7.44	--	--

^aMean + S.D.; T = Temperature abused; N = Not temperature abused.



Table 227. Effect of freezing rate on percent change in patty thickness during cooking for ground beef patties without soy at various storage periods

Evaluation time	Freezing rate, hours to 0°F		
	24	48	72
Immediately before freezing	+38.93 ± 1.90b	+23.49 ± 1.90a	+42.71 ± 1.90b
6 months	-19.35 ± .70ab	-18.49 ± .70ab	-18.04 ± .75b
			+24.57 ± 1.90a
			-20.93 ± .70a

ab Means on the same line with different letters are different ($P < .05$); Mean ± S.E.

Table 228. Effect of final storage temperature on percent change in patty thickness during cooking for ground beef patties without soy following six months storage

Final storage temperature, °F			
-10T	0T	20T	20N
-17.79 \pm .70b	-18.06 \pm .70b	-19.04 \pm .70b	-21.93 \pm .70a

ab Means on the same line with different letters are different ($P < .05$); Mean \pm S.E.; T = Temperature abused; N = Not temperature abused.

Table 229. Interaction effect of final storage temperature and rate of freezing on percent change in patty thickness during cooking for ground beef patties without soy following twelve months storage

Final storage temperature, 0°F	Freezing rate, hours to 0°F			
	24	48	72	96
-10T	- 8.14 ± 1.37d	-19.30 ± 1.37ab	-18.78 ± 1.37ab	-18.81 ± 1.37ab
0T	- 8.90 ± 1.37d	-21.09 ± 1.37a	-20.53 ± 1.37a	-18.75 ± 1.37ab
0N	-12.36 ± 1.37bcd	-10.87 ± 1.37cd	-14.99 ± 1.37abcd	-17.01 ± 1.37abc

abcd Any mean comparison with different letters is different ($P < .05$); Mean ± S.E.;
T = Temperature abused; N = Not temperature abused.



24 hour rate did not differ from the other rates. The same situation also occurred at that storage time for patties initially stored at -10°F (Table 230). Table 231 shows the greater reduction in patty thickness during cooking for patties from the 0°F in 96 hour rate at eighteen months vs the 0°F in 24 hour rate.

As mentioned earlier, nonfrozen patties underwent a swelling in thickness during cooking, while immediately frozen patties decreased slightly in thickness and patties following storage exhibited substantial shrinkage in thickness (Table 232). Longer storage (nine vs twelve months, twelve vs eighteen months) also illustrated more patty thickness shrinkage during cooking. Between six and nine months, patties had less patty thickness shrinkage for all rates, except for the 0°F in 72 hour rate (Table 233). All the temperature combinations for the 0°F in 72 hour rate at twelve months had more thickness shrinkage compared to just after freezing (Table 234). The same was true for 0°F in 48 hour frozen patties stored finally at 0°F . All temperature combinations for the 0°F in 24 and 48 hour rates produced more shrink in patty thickness at eighteen months, except for the patties stored initially at -10°F and initially and finally at 0°F (Table 235).

General values for change in patty diameter during cooking are shown in Table 236. Values were variable and followed no real trend. A significant interaction of initial-final storage temperature and freezing rate was noted at six months, although differences were few and followed no trend (Table 237). Nonabused product had more diameter reduction than abused product following six months of storage (Tables 238, 239). At twelve months of storage, patties from the -10°F initial temperature, 0°F

Table 230. Interaction effect of temperature abuse and rate of freezing on percent change in patty thickness during cooking for ground beef patties without soy following twelve months storage

Temperature abuse	Freezing rate, hours to 0°F			
	24	48	72	96
T	- 7.64 \pm 1.70c	-19.38 \pm 1.70a	-18.85 \pm 1.70ab	-18.83 \pm 1.70ab
N	-10.64 \pm 1.70bc	- 9.45 \pm 1.70c	-15.74 \pm 1.70abc	-19.61 \pm 1.70a

abc Any mean comparison with different letters is different ($P < .05$); Mean \pm S.E.;
 T = Temperature abused; N = Not temperature abused. Includes only -10°F initial storage temperature.



Table 231. Effect of freezing rate on percent change in fatty thickness during cooking of ground beef patties without soy following eighteen months storage

Freezing rate, hours to °F			
24	48	72	96
-14.66 \pm 1.01b	-17.37 \pm 1.01ab	-19.43 \pm 1.43ab	-23.76 \pm 1.01a

ab Means on the same line with different letters are different ($P < .05$); Mean \pm S.E.; T = Temperature abused; N = Not temperature abused. -10°F final temperature of stored product.



Table 232. Effect of various storage time comparisons on percent change in patty thickness during cooking for ground beef patties without soy

<u>Evaluation time</u>	
<u>Immediately before freezing</u>	<u>Immediately following freezing, 1 day</u>
+32.42 \pm 1.73b	-6.21 \pm 1.93a
<u>Immediately following freezing, 1 day</u>	<u>6 months</u>
-6.08 \pm 1.27b	-19.23 \pm 1.27a
<u>Immediately following freezing, 1 day</u>	<u>12 months^c</u>
-6.13 \pm 1.36b	-15.79 \pm 1.36a
<u>Immediately following freezing, 1 day</u>	<u>12 months^d</u>
-5.75 \pm 1.73b	-15.01 \pm 1.73a
<u>9 months</u>	<u>12 months</u>
-8.68 \pm 1.01b	-16.79 \pm .98a
<u>Immediately following freezing, 1 day</u>	<u>18 months^e</u>
-6.06 \pm 1.01b	-16.37 \pm 1.01a
<u>Immediately following freezing, 1 day</u>	<u>18 months^f</u>
-6.01 \pm 1.98b	-18.45 \pm 1.98a
<u>12 months^f</u>	<u>18 months^f</u>
-13.86 \pm .71b	-19.42 \pm 1.07a
<u>12 months^e</u>	<u>18 months^e</u>
-11.61 \pm 1.19b	-16.73 \pm 1.19a

ab Differences between means on the same line are significant ($P < .05$);

Mean \pm S.E.

^cIncludes just temperature abused product for product finally stored at -10°F

^dIncludes just -10°F initial storage temperature.

^eIncludes just 0°F in 24 and 48 hr freezing rates.

^fIncludes just -10°F final storage temperature.



Table 234. Interaction effect of storage time (immediately following freezing, twelve months), initial and final storage temperature and rate of freezing on percent change in patty thickness during cooking for ground beef patties without soy

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to °F			
			24	48	72	96
Immediately following freezing, 1 day						
12 months	-10		- 7.92 + 2.38abcd	- 4.70 + 3.50cd	+ .16 + 2.38d	-12.07 + 2.38abcd
		-10T	- 8.87 + 2.38abcd	-18.16 + 2.38abc	-18.21 + 2.38abc	-19.22 + 2.38abc
		OT	- 6.41 + 2.38bcd	-20.59 + 2.38ab	-19.48 + 2.38ab	-18.44 + 2.38abc
	ON	-10.74 + 2.38abcd	-10.69 + 2.38abcd	-15.13 + 2.38abc	-17.65 + 2.38abc	
	0	-10T	- 7.42 + 2.38abcd	-20.43 + 2.38ab	-19.35 + 2.38ab	-18.41 + 2.38abc
		OT	-11.39 + 2.38abcd	-21.59 + 2.38a	-21.59 + 2.38a	-19.06 + 2.38abc
ON		-13.97 + 2.38abcd	-11.05 + 2.38abcd	-14.84 + 2.38abc	-16.37 + 2.38abc	

abcd Any mean comparison with the same letters is not different ($P>.05$); Mean + S.E.; T = Temperature abused;
N = Not temperature abused.

Table 235. Interaction effect of storage time (immediately following freezing, eighteen months), initial and final storage temperatures and rate of freezing on percent change in patty thickness during cooking for ground beef patties without soy

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F	
			24	48
Immediately following freezing, 1 day				
18 months	-10	-10	- 7.92 + 1.28cd	- 4.21 + 1.28d
		0	-12.02 + 1.28bc	-18.48 + 1.28ab
			-15.20 + 1.28abc	-19.65 + 1.28a
	0	-10	-17.30 + 1.28ab	-16.25 + 1.28ab
		0	-13.98 + 1.28abc	-18.09 + 1.28ab

abcd Any mean comparison with the same letters is not different ($P>.05$); Mean + S.E.



Table 236. General table illustrating percent change in patty diameter during cooking for ground beef patties without soy throughout storage and according to final storage temperature and rate of freezing - no statistical analysis^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Before freezing		-19.73 ± 2.44	-21.04 ± 3.64	-19.84 ± 2.56	-18.22 ± 3.49
Immediately following freezing, 1 day		-21.85 ± 2.21	-20.69 ± 2.44	-21.61 ± 2.64	-20.01 ± 2.25
6 months	-10T	-20.95 ± 2.30	-19.26 ± 2.33	-20.03 ± 2.37	-19.81 ± 1.96
	0T	-19.49 ± 2.82	-20.00 ± 2.19	-19.42 ± 1.81	-21.84 ± 2.51
	20T	-19.93 ± 2.62	-20.54 ± 2.48	-19.91 ± 1.30	-21.01 ± 2.39
	20N	-20.13 ± 1.42	-21.36 ± 2.08	-21.58 ± 2.12	-22.19 ± 2.31
9 months	-10T	-20.04 ± 2.46	-22.60 ± 2.32	-21.61 ± 3.00	-20.59 ± 2.96
	0T	-21.16 ± 3.10	-21.98 ± 1.89	-21.52 ± 2.28	-21.47 ± 2.74
12 months	-10T	-19.74 ± 2.00	-21.10 ± 3.14	-20.53 ± 3.95	-20.57 ± 2.38
	-10N	-20.49 ± 1.42	-22.22 ± 2.42	-19.42 ± 2.11	-22.06 ± 1.76
	0T	-19.89 ± 1.97	-21.04 ± 2.02	-21.15 ± 2.84	-20.89 ± 2.70
	0N	-21.59 ± 2.29	-21.02 ± 2.23	-19.34 ± 1.92	-21.40 ± 1.65
18 months	-10N	-20.59 ± 1.57	-22.04 ± 1.98	-20.96 ± 1.90	-18.23 ± 2.67
	0N	-19.19 ± 1.86	-21.45 ± 2.03		

^a Mean ± S.D. T = temperature abused, N = not temperature abused.

Table 237. Interaction effect of initial storage temperature, final storage temperature and freezing rate on percent change in patty diameter during cooking for ground beef patties without soy following six months of storage

Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
-10	-10T	-20.47 + .64abc	-19.25 + .64abc	-20.12 + .64abc	-20.08 + .64abc
	0T	-18.89 + .64abc	-19.45 + .64abc	-19.42 + .64abc	-21.41 + .64abc
	20T	-18.43 + .64c	-21.54 + .64abc	-19.80 + .64abc	-19.48 + .64abc
	20N	-20.33 + .64abc	-20.30 + .64abc	-22.96 + .64a	-22.91 + .64a
0	-10T	-21.42 + .64abc	-19.27 + .64abc	-19.94 + .64abc	-19.53 + .64abc
	0T	-20.08 + .64abc	-20.55 + .64abc	-19.41 + .64abc	-22.26 + .64abc
	20T	-21.43 + .64abc	-19.54 + .64abc	-20.03 + .64abc	-22.54 + .64ab
	20N	-19.94 + .64abc	-22.42 + .64ab	-20.20 + .64abc	-21.46 + .64abc

abc Any mean comparison with the same letters is not different ($P>.05$). Mean \pm S.E. T = temperature abused, N = not temperature abused.



Table 238. Effect of temperature abuse on percent change in patty diameter during cooking for ground beef patties without soy following six months storage

Temperature abuse	
T	N
-19.04b	-21.93a

ab Difference between means significant ($P < .05$); Mean.
T = Temperature abused;
N = Not temperature abused.

Table 239. Effect of temperature abuse on percent change in patty diameter during cooking for ground beef patties without soy following six months storage

Temperature abuse	
T	N
-20.35b	-21.32a

ab Difference between means significant ($P < .05$) Mean \pm S.E. Includes just +20°F final storage temperature.

final temperature and 0°F in 72 hour rate had more reduction in patty diameter than patties from the -10°F initial-final storage for the same rate (Table 240). Following twelve months of storage, there was indications that temperature abuse reduced patty diameter shrink if final storage was at -10°F; the opposite was the case at 0°F final storage (Table 241). More diameter shrink was observed for 0°F in 48 hour frozen product subjected to nonabuse and -10°F final storage compared to 0°F in 96 hour frozen product (Table 242) after eighteen months storage. Patties at this time that were frozen to 0°F in 48 hours had more diameter shrinkage than patties from the 0°F in 24 hour rate.

After six months of storage, none of the initial-final temperature-freezing rate combinations differed ($P > .05$) from just post-freezing in percent change in patty diameter (Table 243). Greater reduction in patty diameter during cooking was noted after nine months than six months only for patties frozen to 0°F in 48 hours (Table 244). Between nine and twelve months, patty diameter shrink went down for patties from the 0°F in 72 hour rate initially and finally stored at 72°F (Table 245). There were indications of reductions in patty diameter shrinkage from just after freezing until twelve months for patties of the 0°F in 24 and 72 hour rate initially and finally stored at -10°F (Table 246). Patties from the 0°F in 96 hour rate declined in the percent diameter shrink from twelve to eighteen months (Table 247).

General data for percent moisture in raw patties (Table 248) shows a slight decline as a result of storage (mainly eighteen months) and slightly lower values with +20°F storage. The 0°F in 48 hour rate produced higher moisture values than all other rates at nine months and the 0°F in 24 hour

Table 240. Interaction effect of initial and final storage temperature and rate of freezing on percent change in patty diameter during cooking for ground beef patties without soy following twelve months of storage

Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
-10	-10T	-19.72 + .52abc	-21.10 + .52abc	-18.70 + .52c	-20.70 + .52abc
	0T	-19.76 + .52abc	-21.16 + .52abc	-22.02 + .52ab	-21.31 + .52abc
	0N	-20.88 + .52abc	-21.19 + .52abc	-19.23 + .52bc	-20.63 + .52abc
0	-10T	-19.76 + .52abc	-21.10 + .52abc	-22.37 + .52a	-20.44 + .52abc
	0T	-20.02 + .52abc	-20.91 + .52abc	-20.28 + .52abc	-20.47 + .52abc
	0N	-22.31 + .52a	-20.85 + .52abc	-19.45 + .52abc	-22.16 + .52ab

abc Any mean comparison with the same letters is not different ($P>.05$). Mean + S.E. T = temperature abused,
N = not temperature abused.



Table 241. Interaction effect of temperature abuse and final storage temperature on percent change in patty diameter during cooking for ground beef patties without soy following twelve months storage^a

Temperature abuse	Final storage temperature, °F	
	-10	0
T	-20.06 ± .28	-21.06 ± .28
N	-21.05 ± .28	-20.48 ± .28

^a Interaction significant by analysis of variance ($P < .05$), but not by HSD. T = temperature abused, N = not temperature abused. Includes just -10°F initial storage temperature.

Table 242. Effect of freezing rate on percent change in patty diameter during cooking for ground beef patties without soy following eighteen months storage

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
18 ^c	-20.59 ± .50ab	-22.04 ± .50a	-20.96 ± .70ab	-18.23 ± .50b
18 ^d	-19.89 ± .38b	-21.75 ± .38a		

ab Means on the same line with the same letters are not different ($P > .05$).
Mean ± S.E.

c Includes just nonabused -10°F final temperature stored product.

d Includes both 0°F and -10°F final temperature stored product.

Table 243. Interaction effect of storage time (immediately following freezing, six months), initial and final storage temperature and freezing rate on percent change in patty diameter during cooking for ground beef patties without soy

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F			
			24	48	72	96
Immediately following freezing, 1 day						
6 months	-10		-21.85 + .71ab	-20.69 + .71ab	-21.61 + .71ab	-20.01 + .71ab
		-10T	-20.47 + .71ab	-19.25 + .71ab	-20.12 + .71ab	-20.08 + .71ab
		0T	-18.89 + .71ab	-19.45 + .71ab	-19.42 + .71ab	-21.41 + .71ab
		20T	-18.43 + .71b	-21.54 + .71ab	-19.80 + .71ab	-19.48 + .71ab
		20N	-20.33 + .71ab	-20.30 + .71ab	-22.96 + .71a	-22.91 + .71a
	0		-21.42 + .71ab	-19.27 + .71ab	-19.94 + .71ab	-19.53 + .71ab
		-10T	-20.08 + .71ab	-20.55 + .71ab	-19.41 + .71ab	-22.26 + .71ab
		20T	-21.44 + .71ab	-19.54 + .71ab	-20.03 + .71ab	-22.54 + .71ab
		20N	-19.94 + .71ab	-22.42 + .71ab	-20.20 + .71ab	-21.46 + .71ab

ab Any mean comparison with the same letters is not different (P>.05). Mean ± S.E. T = temperature abused, N = not temperature abused.



Table 244. Interaction effect of storage time (six, nine months) and freezing rate on percent change in diameter during cooking for ground beef patties without soy

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
6	-20.22 \pm .41b	-19.63 \pm .41b	-19.72 \pm .41b	-20.82 \pm .41ab
9	-20.60 \pm .41ab	-22.29 \pm .41a	-21.57 \pm .41ab	-21.03 \pm .41ab

ab Any mean comparison with the same letters are not different ($P > .05$).
Mean \pm S.E.

Table 245. Interaction effect of storage time (nine, twelve months), initial and final storage temperature and rate of freezing on percent change in patty diameter during cooking for ground beef patties without soy

Evaluation time, months	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F			
			24	48	72	96
9	-10	-10	-19.76 + .44cd	-23.36 + .44a	-21.70 + .44abc	-21.14 + .44abcd
		0	-19.74 + .44cd	-22.46 + .44abc	-21.26 + .44abcd	-22.67 + .44ab
	0	-10	-20.32 + .44bcd	-21.84 + .44abc	-21.53 + .44abc	-20.04 + .44bcd
		0	-22.58 + .44ab	-21.50 + .44abcd	-21.78 + .44abc	-20.28 + .44bcd
12	-10	-10	-19.72 + .44cd	-21.10 + .44abcd	-18.70 + .44d	-20.70 + .44abcd
		0	-19.76 + .44cd	-21.16 + .44abcd	-22.02 + .44abc	-21.31 + .44abcd
	0	-10	-19.76 + .44cd	-21.10 + .44abcd	-22.37 + .44abc	-20.44 + .44bcd
		0	-20.02 + .44bcd	-20.91 + .44abcd	-20.28 + .44bcd	-20.47 + .44bcd

abcd Any mean comparison with the same letters is not different ($P>.05$). Mean + S.E.



Table 246. Interaction effect of storage time (immediately following freezing, twelve months), initial and final storage temperature and rate of freezing on percent change in patty diameter during cooking for ground beef patties without soy^a

Evaluation time	Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F			
			24	48	72	96
Immediately following freezing, 1 day			-21.85 ± .62	-20.69 ± .62	-21.61 ± .62	-20.01 ± .62
12 months	-10	-10T	-19.72 ± .62	-21.10 ± .62	-18.70 ± .62	-20.70 ± .62
		0T	-19.76 ± .62	-21.16 ± .62	-22.02 ± .62	-21.31 ± .62
		0N	-20.88 ± .62	-21.19 ± .62	-19.23 ± .62	-20.63 ± .62
	0	-10T	-19.76 ± .62	-21.10 ± .62	-22.37 ± .62	-20.44 ± .62
		0T	-20.02 ± .62	-20.91 ± .62	-20.28 ± .62	-20.47 ± .62
		0N	-22.31 ± .62	-20.85 ± .62	-19.45 ± .62	-22.16 ± .62

^a Interaction significant ($P < .05$) by analysis of variance, but not by HSD. Mean ± S.E. T = temperature abused, N = not temperature abused.



Table 247. Interaction effect of storage time (twelve, eighteen months) and rate of freezing on percent change in patty diameter during cooking for ground beef patties without soy

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
12	-20.69 ± .52ab	-21.70 ± .52a	-19.33 ± .52ab	-21.35 ± .52a
18	-19.75 ± .52ab	-21.27 ± .52a	-20.56 ± 1.17ab	-17.79 ± .74b

ab Any mean comparison with the same letters is not different ($P > .05$).
Mean ± S.E. Includes only -10°F final storage temperature.

Table 248. General table illustrating the percent moisture in raw ground beef patties without soy throughout storage times and according to final storage temperature and freezing rate - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Before freezing		63.59 ± .04	63.35 ± .98	62.64 ± .18	63.64 ± .41
Immediately after freezing, 1 day		62.56 ± .98	63.63 ± .75	62.40 ± 1.15	63.73 ± .55
6 months	-10 T	62.32 ± 1.61	62.04 ± 1.31	62.4 ± 1.58	62.02 ± 1.40
	0 T	61.08 ± 1.13	62.08 ± .81	62.84 ± .90	62.22 ± .29
	20 T	61.68 ± .98	63.85 ± 1.15	60.0 ± 1.07	61.50 ± .47
	20 N	60.28 ± 1.32	62.53 ± .56	61.6 ± .49	62.85 ± .92
9 months	-10 T	62.07 ± .87	63.13 ± .23	62.46 ± .61	62.6 ± .93
	0 T	62.63 ± .77	63.7 ± .75	61.32 ± .37	62.03 ± .63
12 months	-10 T	61.8 ± 1.34	63.00 ± .93	61.79 ± 1.41	62.66 ± 1.24
	-10 N	63.15 ± .56	63.44 ± .58	62.21 ± --	62.31 ± .84
	0 T	62.15 ± 1.77	62.45 ± .92	62.41 ± .44	62.71 ± .75
	0 N	62.28 ± .35	64.12 ± .74	61.24 ± 1.03	62.36 ± 2.17
18 months	-10 N	61.23 ± .38	62.05 ± .32	61.19 ± .77	61.13 ± .40
	0 N	61.31 ± .43	61.71 ± .090	--	--

^aMean ± S.D.; T = temperature abused; N = not temperature abused.



rate at eighteen months (Table 249). After six months of storage, the 0°F in 72 hour rate produced less moisture in raw patties than the 0°F in 48 hour rate only for product receiving temperature abuse and +20°F storage (Table 250). Percent moisture in raw patties was higher in 0°F in 72 hour frozen patties if initial storage was at 0°F rather than -10°F (Table 251).

Comparisons of just post-freezing with eighteen months of storage or twelve with eighteen months of storage showed moisture decreases with advancing storage (Table 252). Regardless of initial and final storage temperature and freezing rate, percent moisture didn't change during the first six months of storage (Table 253). Between twelve and eighteen months, the decline in percent moisture was greater for patties from the 0°F in 48 hour rate than the 0°F in 24 hour rate (Table 254). Also, between twelve and eighteen months, percent moisture decreased more for patties stored initially at -10°F in contrast to those held at 0°F (Table 255).

General values for percent fat in ground beef patties in the raw state are depicted in Table 256. Values were variable and followed no real trend. Following six months of storage, patties from the 0°F in 72 hour rate had more fat than those from the 0°F in 48 hour rate if final storage was maintained at +20°F and included temperature abuse (Table 257). At eighteen months of storage, patties frozen to 0°F in 24 hours had more fat in the raw state than patties frozen to 0°F in 48 hours (Table 258).

In comparing six months with just post-freezing, the only difference was the increase in fat percent during this storage for patties initially stored at 0°F and finally at +20°F and also included temperature abuse (Table 259). Between twelve and eighteen months fat level increased for

Table 249. Effect of freezing rate on percent moisture in raw ground beef patties without soy at various storage times

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
9	62.35 \pm 0.24b	63.41 \pm 0.24a	61.89 \pm 0.24b	62.32 \pm 0.24b
18	61.27 \pm 0.12b	61.88 \pm 0.12a	--	--

ab Means on the same line with different letters are different ($P < .05$); Mean \pm S.E.



Table 250. Interaction effect of final storage temperature and rate of freezing on percent moisture in raw ground beef patties without soy following six months of storage

Final Storage Temperature, °F	Freezing Rate, hours to 0°F			
	24	48	72	96
-10 T	62.32 \pm 0.50abc	62.04 \pm 0.50abc	62.39 \pm 0.50abc	62.02 \pm 0.50abc
0 T	61.07 \pm 0.50bc	62.08 \pm 0.50abc	62.84 \pm 0.50ab	62.22 \pm 0.50abc
+20 T	61.68 \pm 0.50abc	63.85 \pm 0.50a	60.0 \pm 0.50c	61.5 \pm 0.50abc
+20 N	60.28 \pm 0.50bc	62.53 \pm 0.50abc	61.6 \pm 0.50abc	62.85 \pm 0.50ab

abc Any mean comparisons with the same letters are not different ($P > .05$); Mean \pm S.E.;
T = temperature abused; N = not temperature abused.

Table 251. Interaction effect of initial storage temperature and rate of freezing on percent moisture in raw ground beef patties without soy following eighteen months of storage

Initial Storage Temperature, °F	Freezing Rate, hours to 0°F			
	24	48	72	96
-10	61.45 \pm 0.12abc	61.81 \pm 0.12ab	60.38 \pm 0.12c	61.42 \pm 0.12abc
0	61.01 \pm 0.12bc	62.28 \pm 0.12a	62.00 \pm 0.12ab	60.83 \pm 0.12bc

abc Any mean comparisons with the same letters are not different ($P > .05$); Mean \pm S.E.

Table 252. Effects of various storage time comparisons on percent moisture in raw ground beef patties without soy

Evaluation time ^c	
Immediately following freezing, 1 day	18 months
63.09 \pm .51a	61.81 \pm .51b

Evaluation time ^d	
Immediately following freezing, 1 day	18 months
63.08 \pm .36a	61.30 \pm .25b

Evaluation time	
12 months	18 months
62.57 \pm .17a	61.30 \pm .25b

ab Differences between means significant ($P < .05$). Mean \pm S.E.

^cIncludes only 0°F in 24 and 48 hr freezing rates.

^dIncludes all four rates of freezing.

Table 253. Interaction effect of storage time (immediately following freezing, six months) initial storage temperature, final storage temperature and rate of freezing on percent moisture in raw ground beef patties without soy

			Freezing rate, hours to 0°F				
			24	48	72	96	
Immediately following freezing, 1 day			62.56 + .69abc	63.63 + .69ab	62.40 + .69abc	63.73 + .69ab	
Evaluation time, months	Initial storage temp, °F	Final storage temp, °F					
	6	-10	-10 T	63.25 + .69abc	61.01 + .69abc	62.47 + .69abc	63.00 + .69abc
			0 T	60.59 + .69abc	61.8 + .69abc	63.23 + .69abc	62.40 + .69abc
			20 T	62.05 + .69abc	64.66 + .69a	60.76 + .69abc	61.85 + .69abc
			20 N	60.30 + .69bc	62.19 + .69abc	61.41 + .69abc	62.07 + .69abc
0	-10 T	-10 T	61.39 + .69abc	63.07 + .69abc	62.32 + .69abc	61.05 + .69abc	
		0 T	61.56 + .69abc	62.36 + .69abc	62.44 + .69abc	62.04 + .69abc	
		20 T	61.30 + .69abc	63.05 + .69abc	59.23 + .69c	61.14 + .69abc	
		20 N	60.25 + .69bc	62.88 + .69abc	61.79 + .69abc	63.63 + .69ab	

abc Any mean comparisons with the same letter are not different ($P > .05$). Mean ± S.E.; T = temperature abused;
N = not temperature abused.

Table 254. Interaction effect of storage time (twelve, eighteen months) and rate of freezing on percent moisture in raw ground beef patties without soy

Evaluation time, months	Freezing rate, hours to 0°F	
	24	48
12	62.28 \pm .15b	64.12 \pm .15a
18	61.31 \pm .15c	61.71 \pm .15bc

ab Any mean comparison with different letters is different ($P < .05$); Mean \pm S.E.

Table 255. Interaction effect of storage time (twelve, eighteen months) and initial storage temperature on percent moisture in raw ground beef patties without soy

Evaluation time, months	Initial storage temperature, °F	
	-10	0
12	63.58 \pm .15a	62.82 \pm .15a
18	61.48 \pm .15b	61.54 \pm .15b

ab Any mean comparison with different letters is different ($P < .05$); Mean \pm S.E.

Table 256. General table illustrating the percent fat in raw ground beef patties without soy throughout storage times and according to final storage temperature and freezing rate - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Before freezing		20.16 ± .27	19.21 ± 1.60	21.28 ± .63	20.11 ± .32
Immediately after freezing, 1 day		21.22 ± .92	20.42 ± .38	19.85 ± 1.29	20.16 ± .76
6 months	-10 T	20.68 ± 1.43	20.71 ± 1.22	21.08 ± 1.49	20.88 ± 1.12
	0 T	21.85 ± .82	20.66 ± .74	20.94 ± .73	20.74 ± .21
	20 T	21.07 ± .97	19.13 ± .79	23.16 ± 1.05	21.36 ± .39
	20 N	22.74 ± 1.17	20.57 ± .62	21.62 ± .43	20.35 ± .75
9 months	-10 T	20.8 ± 1.09	20.58 ± .14	20.68 ± .65	20.45 ± .75
	0 T	20.45 ± .78	20.17 ± .62	21.61 ± .47	20.76 ± .61
12 months	-10 T	21.66 ± 1.19	20.64 ± .98	21.67 ± 1.30	20.97 ± 1.27
	-10 N	20.68 ± .26	20.20 ± .027	21.33 ± --	21.16 ± .23
	0 T	21.23 ± 1.49	21.12 ± .88	20.97 ± .47	20.90 ± .70
	0 N	21.50 ± .29	19.71 ± 1.03	22.36 ± 1.30	21.27 ± 1.73
18 months	-10 N	21.53 ± .22	20.82 ± .22	21.67 ± .53	21.24 ± .35
	0 N	21.65 ± .37	20.89 ± .46	--	--

^aMean ± S.D.; T = temperature abused; N = not temperature abused.

Table 257. Interaction effect of final storage temperature and rate of freezing on percent fat in raw ground beef patties without soy following six months of storage

Final Storage Temperature, °F	Freezing Rate, hours to 0°F			
	24	48	72	96
-10 T	20.68 \pm 0.45bc	20.71 \pm 0.45bc	21.08 \pm 0.45abc	20.88 \pm 0.45abc
0 T	21.85 \pm 0.45ab	20.66 \pm 0.45bc	20.94 \pm 0.45abc	20.74 \pm 0.45abc
+20 T	21.07 \pm 0.45abc	19.13 \pm 0.45c	23.16 \pm 0.45a	21.37 \pm 0.45abc
+20 N	22.74 \pm 0.45ab	20.57 \pm 0.45bc	21.62 \pm 0.45ab	20.35 \pm 0.45bc

abc Any mean comparisons with different letters are different ($P < .05$). Mean \pm S.E.;
T = temperature abused; N = not temperature abused.



Table 258. Effect of freezing rate on percent fat in raw ground beef patties without soy following eighteen months storage

<u>Freezing rate, hours to 0°F</u>	
<u>24</u>	<u>48</u>
21.59 \pm 0.13 a	20.86 \pm 0.13b

ab Difference between means significant ($P < .05$)
Mean \pm S.E.

Table 259. Interaction effect of storage time (immediately following freezing, six months) initial storage temperature, final storage temperature and rate of freezing on percent fat in raw ground beef patties without soy

			Freezing rate, hours to 0°F			
			24	48	72	96
Immediately following freezing, 1 day			21.22 ± .63abc	20.42 ± .63abc	19.85 ± .63bc	20.16 ± .63abc
Evaluation time, months	Initial storage temp, °F	Final storage temp, °F				
6	-10	-10 T	19.74 ± .63bc	21.63 ± .63abc	21.30 ± .63abc	20.12 ± .63abc
		0 T	22.17 ± .63abc	20.85 ± .63abc	20.55 ± .63abc	20.67 ± .63abc
		20 T	20.7 ± .63abc	18.54 ± .63c	22.42 ± .63ab	21.19 ± .63abc
		20 N	22.91 ± .63ab	20.93 ± .63abc	21.78 ± .63abc	20.99 ± .63abc
	0	-10 T	21.63 ± .63abc	19.79 ± .63bc	20.86 ± .63abc	21.64 ± .63abc
		0 T	21.52 ± .63abc	20.48 ± .63abc	21.32 ± .63abc	20.82 ± .63abc
		20 T	21.45 ± .63abc	19.72 ± .63bc	23.89 ± .63a	21.54 ± .63abc
		20 N	22.56 ± .63ab	20.20 ± .63abc	21.45 ± .63abc	19.72 ± .63bc

abc Any mean comparisons with the same letter are not different ($P > .05$). Mean ± S.E.; T = temperature abused; N = not temperature abused.

patties frozen to 0°F in 48 hours, but no increase was found for those frozen to 0°F in 24 hours (Table 260). Percent fat increased between just after freezing and eighteen months of storage (Table 261).

General values for percent moisture in cooked ground beef patties without soy is shown in Table 262. Freezing in itself produced a sizable decrease in the percentage of moisture remaining in the patties following cooking. Final storage at +20°F also decreased the cooked patty moisture content. Values shown in Table 263 indicate this greater reduction in moisture found in cooked patties when storage occurred at +20°F, however, these differences were not present in all situations. Faster freezing rates produced higher moisture contents in cooked patties when evaluations occurred at nine and twelve months (Table 264). At twelve months of storage, temperature abuse reduced the moisture level in cooked patties for those stored finally at -10°F; no effect was detected for patties held finally at 0°F (Table 265). Within temperature abuse at this time, 0°F final storage allowed for more moisture retention during cooking than -10°F storage (Table 266). After eighteen months of storage, there were indications that 0°F in 24 hour freezing left more moisture in cooked patties than 0°F in 48 and 96 hour freezing (Table 267).

As noted earlier, freezing in itself reduced, considerably, the moisture in cooked patties regardless of freezing rate. Also, comparisons of just post-freezing with nine and twelve months storage showed moisture declines with storage (Table 268). However, moisture levels increased between six and nine months. Patties initially held at -10°F and finally at 0°F and the reciprocal temperature combination of this showed moisture reductions in cooked patties after nine months vs just post-freezing

Table 260. Interaction effect of storage time (twelve, eighteen months) and rate of freezing on percent fat in raw ground beef patties without soy

Evaluation time, months	Freezing rate, hours to 0°F	
	24	48
12	21.5 \pm .15a	19.71 \pm .15b
18	21.65 \pm .15a	20.89 \pm .15a

ab Any mean comparison with the same letter is not different ($P > .05$); Mean \pm S.E.

Table 261. Effect of storage time
(immediately after freezing, eighteen
months) on percent fat in raw ground
beef patties without soy

Evaluation Time	
Immediately following freezing 1 day	18 months
20.41 \pm .36a	21.38 \pm .36b

ab Difference between means is
significant ($P < .05$); Mean \pm S.E.

Table 262. General table illustrating the percent moisture in cooked beef patties without soy throughout storage times and according to final storage temperature and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Before freezing		55.09 ± .05	54.5 ± .43	55.24 ± .11	54.85 ± 1.35
Immediately after freezing, 1 day		51.89 ± .36	51.35 ± .29	50.06 ± .94	49.83 ± .57
6 months	-10 T	50.43 ± 1.09	49.76 ± 1.0	48.3 ± .66	48.09 ± .38
	0 T	50.29 ± .43	49.88 ± .57	48.4 ± 1.24	48.38 ± .57
	20 T	49.26 ± .33	47.93 ± .71	47.32 ± .77	47.42 ± .38
	20 N	48.94 ± .93	48.17 ± .83	47.8 ± .61	47.95 ± 1.10
9 months	-10 T	51.33 ± .83	49.97 ± .88	48.9 ± .62	48.42 ± .34
	0 T	50.89 ± .71	50.55 ± .30	49.21 ± .40	48.88 ± .34
12 months	-10 T	50.77 ± .52	50.3 ± .57	49.86 ± .76	48.62 ± .46
	-10 N	51.10 ± .47	50.07 ± .26	50.53 ± .61	48.98 ± .02
	0 T	51.18 ± .60	50.21 ± .28	50.23 ± .13	49.5 ± .14
	0 N	51.43 ± .73	50.16 ± .36	50.56 ± .39	48.8 ± .48
18 months	-10 N	50.82 ± .54	49.83 ± .36	49.0 ± .15	48.05 ± .61
	0 N	50.24 ± .62	49.86 ± .40	--	--

^aMean ± S.D.; T = temperature abused; N = not temperature abused.



Table 263. General table illustrating the percent moisture in cooked beef patties without soy following six months of storage according to initial storage temperature, final storage temperature and rate of freezing^a

Initial Storage Temperature, °F	Final Storage Temperature, °F	Temperature Abuse	Freezing Rate, hours to 0°F			
			24	48	72	96
-10	-10	T	51.1 + .72	50.0 + .76	48.3 + .75	48.3 + .25
-10	0	T	50.6 + .16	49.9 + .77	47.6 + 1.47	48.5 + .42
-10	+20	T	49.3 + .54	48.8 + .41	47.5 + .90	47.2 + .50
-10	+20	N	49.3 + 1.38	47.7 + .67	47.3 + .94	48.9 + .38
0	-10	T	49.7 + 1.08	49.5 + 1.45	48.2 + .87	47.9 + .41
0	0	T	50.0 + .34	49.8 + .62	49.1 + .50	48.3 + .87
0	+20	T	49.2 + .07	47.6 + .93	47.1 + .31	47.6 + .04
0	+20	N	48.5 + .23	48.6 + .94	48.3 + .18	47.0 + .37

^aMean + S.D. Data presented at this storage time on this basis due to some missing data preventing statistical analyses. T = temperature abused, N = not temperature abused.



Table 264. Effect of freezing rate on percent moisture in cooked beef patties without soy at various storage times

Evaluation time, months	Freezing rate, hours to 0°F		
	24	48	72
9	51.11 ± .28a	50.26 ± .28ab	49.06 ± .28b
12	51.12 ± .12a	50.22 ± .12b	50.21 ± .12b
12 ^d	51.31 ± .15a	50.13 ± .15b	50.4 ± .15b
			48.65 ± .28b
			48.98 ± .12c
			49.15 ± .15c

abc Means on the same line with different letters are different ($P < .05$).
 d Includes only -10°F initial storage temperature product.



Table 265. Interaction effect of temperature abuse and final storage temperature on percent moisture in cooked beef patties without soy following twelve months of storage

Temperature Abuse	Final storage temperature, °F	
	-10	0
T	49.84 \pm .15b	50.45 \pm .15ab
N	50.5 \pm .15a	50.2 \pm .15ab

ab Any mean comparison with the same letters are not different; Mean \pm S.E. T = temperature abused, N = not temperature abused.



Table 266. Effect of final storage temperature on percent moisture in cooked beef patties without soy following twelve months storage

Final Storage Temperature, °F		
-10 T	0 T	0 N
49.89 \pm .10b	50.28 \pm .10a	50.24 \pm .10ab

ab Means on the same line with the same letter are not different ($P > .05$). Mean \pm S.E. T = temperature abused, N = not temperature abused.



Table 267. General table illustrating percent moisture in cooked beef patties without soy following eighteen months storage according to initial storage temperature, final storage temperature and rate of freezing^a

Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
-10	-10	50.9 + .62	49.9 + .38	50.6 + .59	48.3 + .86
	0	50.2 + .57	49.8 + .61	--	--
0	-10	50.8 + .70	49.7 + .45	48.5 + .21	47.8 + .14
	0	50.3 + .94	49.9 + .34	--	--

^aMean + S.D. Data presented at this storage time on this basis due to some missing data preventing statistical analyses. Includes only non-temperature abused product.

Table 268. Effects of various storage time comparisons on percent moisture in cooked ground beef patties without soy

<u>Storage time comparisons</u>	
<u>Before freezing</u>	<u>Immediately following freezing, 1 day</u>
54.92 \pm .23a	50.78 \pm .23b
<u>Immediately following freezing, 1 day</u>	<u>9 months</u>
50.78 \pm .22a	49.77 \pm .22b
<u>Immediately following freezing, 1 day</u>	<u>12 months</u>
50.78 \pm .21a	50.16 \pm .21b
<u>6 months</u>	<u>9 months</u>
48.6 \pm .096b	49.77 \pm .096a

ab Differences between means within comparisons are significant ($P < .05$). Mean \pm S.E.



Table 269. Effect of storage time (immediately following freezing, nine months) on percent moisture in cooked beef patties without soy

	9 Months Storage			
	Immediately following freezing 1 day			
	Initial Storage Temperature, °F =	-10		0
	Final Storage temperature, °F =	-10	0	-10
50.78 ± .21a	49.91 ± .21ab	49.85 ± .21b	49.40 ± .21b	49.92 ± .21ab

ab Means on the same line with the same letters are not different ($P > .05$). Mean ± S.E.



(Table 269). Between nine and twelve months, moisture increased only for 0°F in 72 hour rate patties (Table 270). Also, between nine and twelve months, those patties at nine months that initially were held at 0°F and finally at -10°F had lower moisture content than patties at twelve months initially held at -10°F and finally at 0°F (Table 271). The reduction in moisture content from 0°F in 96 hour freezing vs 0°F in 24 hour freezing found just post-freezing was also noted at 12 months under most initial-final temperature combinations (Table 272). At eighteen months, regardless of initial storage, patties finally held at 0°F showed less moisture in cooked patties than just after freezing (Table 273).

General values for percent moisture in cooked patties is depicted in Table 274. Freezing, itself, produced a slight increase (due to moisture loss) and the use of +20°F storage elevated percent fat values. At six months of storage, there were indications, regardless of freezing rate, that +20°F final storage allowed for more fat in the cooked patties (Table 275). This was obviously due to there being less moisture in these patties. Patties from the 0°F in 72 hour rate had the highest percent fat in cooked patties after nine months, but the lowest percentage following twelve months (Table 276). Nonabuse reduced the fat level in cooked patties following eighteen months, but only for those stored finally at -10°F (Table 277). There were indications following eighteen months of storage that patties from this rate were low in cooked fat, but only if initially and finally stored at -10°F (Table 278). Freezing, itself, increased the fat in cooked patties, while comparisons at nine and twelve months with just after freezing showed increases in fat (Table 279). Percent fat decreased between six and nine months. At nine months there

Table 270. Interaction effect of storage time (nine, twelve months) and rate of freezing on percent moisture in cooked beef patties without soy

Evaluation Time, months	Freezing rate, hours to 0°F		
	24	48	72
9	51.11 ± .17a	50.26 ± .17bc	49.06 ± .17d
12	50.97 ± .17ab	50.26 ± .17bc	50.04 ± .17c
			48.65 ± .17d
			49.06 ± .17d

abcd Any mean comparison with different letters is different ($P < .05$); Mean ± S.E.



Table 271. Interaction effect of storage time (nine, twelve months) final storage temperature and initial storage temperature on percent moisture in cooked beef patties without soy

Evaluation Time, months	Final Storage Temperature, °F	Initial storage temperature, °C	
		-10	0
9	-10	49.91 \pm .17ab	49.4 \pm .17b
	0	49.85 \pm .17ab	49.92 \pm .17ab
12	-10	49.84 \pm .17ab	49.93 \pm .17ab
	0	50.45 \pm .17a	50.10 \pm .17ab

ab Any mean comparison with the same letter is not different ($P > .05$); Mean \pm S.E.

Table 272. Interaction effect of storage time (immediately following freezing, twelve months) initial storage temperature, final storage temperature and rate of freezing on percent moisture in cooked beef patties without soy

Evaluation time, months	Initial Storage Temp, °F	Final Storage Temp, °F	Freezing Rate, hours to 0°F			
			24	48	72	96
Immediately after freezing, 1 day			51.89 ± .31a	51.35 ± .31abc	50.06 ± .31abcdefg	49.83 ± .31bcdefg
12 months	-10	-10 T	50.39 ± .31abcde	49.83 ± .31bcdefg	50.13 ± .31abcdef	49.01 ± .31efg
		0 T	51.66 ± .31ab	50.43 ± .31abcde	50.13 ± .31abcdef	49.58 ± .31cdefg
		0 N	51.39 ± .31abc	49.94 ± .31bcdefg	50.42 ± .31abcde	49.08 ± .31efg
	0	-10 T	51.14 ± .31abcd	50.78 ± .31abcde	49.58 ± .31cdefg	48.24 ± .31g
		0 T	50.69 ± .31abcde	49.99 ± .31bcdefg	50.32 ± .31abcdef	49.41 ± .31cdefg
		0 N	51.46 ± .31ab	50.38 ± .31abcde	50.7 ± .31abcde	48.53 ± .31fg

abcdefg Any mean comparisons with the same letters are not different ($P > .05$). Mean ± S.E.
T = temperature abused, N = not temperature abused.

Table 273. Effect of storage time (immediately following freezing, eighteen months) on percent moisture in cooked beef patties without soy

18 months storage				
Immediately following freezing, 1 day	Initial Storage temperature, °F =	-10		0
	Final Storage temperature, °F =	-10	0	-10
		53.19 + .2ab	52.73 + .2b	52.82 + .2ab
53.67 + .2a				52.62 + .2b

ab Means on the same line with the same letters are not different ($P > .05$); Mean + S.E.

Table 274. General table illustrating the percent fat in cooked beef patties without soy throughout storage times and according to final storage temperature and rate of freezing - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Temperature abuse	Freezing rate, hours to 0°F			
			24	48	72	96
Before freezing			17.7 ± .32	16.8 ± .67	17.7 ± .68	19.1 ± 1.27
Immediately after freezing, 1 day			19.6 ± 1.0	19.5 ± .33	18.4 ± .70	19.8 ± .51
6 months	-10	T	20.4 ± .84	20.8 ± .46	21.6 ± .64	20.9 ± .42
	0	T	20.3 ± .31	20.6 ± .35	20.5 ± .32	21.0 ± .72
	+20	T	21.1 ± .49	22.3 ± .50	22.0 ± .62	22.0 ± .68
	+20	N	21.9 ± .68	22.0 ± .91	21.9 ± .37	21.8 ± .61
9 months	-10	T	19.4 ± .54	20.2 ± .53	20.5 ± .54	19.9 ± .44
	0	T	19.9 ± .28	20.1 ± .51	20.6 ± .56	19.6 ± .22
12 months	-10	T	20.1 ± .20	20.5 ± .44	19.7 ± .50	21.1 ± .27
	-10	N	19.8 ± .18	20.2 ± .25	18.7 ± .64	20.8 ± .01
	0	T	19.9 ± .46	20.6 ± .18	19.9 ± .36	20.4 ± .16
	0	N	20.1 ± .36	20.5 ± .70	19.7 ± .57	20.6 ± .76
18 months	-10	N	20.4 ± .32	20.8 ± .25	20.6 ± .15	20.8 ± .60
	0	N	20.6 ± .57	20.4 ± .25	--	--

^aMean ± S.D.; T = Temperature abused; N = Not temperature abused.

Table 275. General table illustrating the percent fat in cooked beef patties without soy following six months of storage^a

Initial storage temperature, °F	Final storage temperature, °F	Temperature abuse	Freezing rate, hours to 0°F			
			24	48	72	96
-10	-10	T	20.0 ± .78	20.6 ± .50	21.1 ± .43	21.0 ± .04
	0	T	20.3 ± .07	20.5 ± .44	20.8 ± .03	21.0 ± .34
	+20	T	21.1 ± .01	21.9 ± .05	22.1 ± .91	22.4 ± .80
	+20	N	21.4 ± .08	22.3 ± .60	22.1 ± .34	21.3 ± .05
0	-10	T	20.8 ± .91	21.1 ± .33	22.0 ± .49	20.9 ± .61
	0	T	20.3 ± .53	20.6 ± .41	20.3 ± .20	20.9 ± 1.19
	+20	T	21.2 ± .85	22.6 ± .50	21.9 ± .52	21.7 ± .64
	+20	N	22.3 ± .11	21.7 ± 1.33	21.6 ± .25	22.3 ± .31

^aMean ± S.D. Data presented at this storage time on this basis due to some missing data preventing statistical analyses.



Table 276. Effect of freezing rate on percent fat in cooked patties without soy at various storage times

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
9 ^d	19.67 ± .20	20.15 ± .20	20.53 ± .20	19.78 ± .20
12	20.05 ± .13bc	20.55 ± .13ab	19.79 ± .13c	20.7 ± .13a
12 ^e	19.9 ± .14b	20.56 ± .14a	19.59 ± .14b	20.57 ± .14a

abc Means on the same line with different letters are different ($P < .05$);
Mean ± S.E.

^dDifferences between rate significant by analysis of variance, but not HSD.

^eIncludes only -10°F initial storage temperature.

Table 277. Interaction effect of temperature abuse and final storage temperature on percent fat in cooked beef patties without soy following twelve months of storage^a

Temperature Abuse	Final Storage Temperature, °F	
	-10	0
T	20.45 \pm .14	20.11 \pm .14
N	19.87 \pm .14	20.19 \pm .14

^aDifferences significant ($P < .05$) by analysis of variance but not by HSD; Mean \pm S.E.; T = temperature abused; N = Not temperature abused.

Table 278. General table illustrating the percent fat in cooked beef patties without soy following eighteen months of storage^a

Initial storage temperature, °F	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
-10	-10	20.2 ± .49	20.7 ± .03	18.7 ± .26	20.8 ± 1.02
	0	20.3 ± .78	20.4 ± .42	--	--
0	-10	20.5 ± .12	20.8 ± .41	20.7 ± .071	20.9 ± .16
	0	20.8 ± .36	20.5 ± .07	--	--

^aMean + S.D. Data presented at this storage time on this basis due to some missing data preventing statistical analyses.

Table 279. Effects of various storage time comparisons on percent fat in cooked beef patties without soy at various storage times

Evaluation times	
Before freezing	Immediately following freezing, 1 day
17.85 \pm .23b	19.33 \pm .23a
Immediately following freezing, 1 day	9 months
19.33 \pm .20b	20.03 \pm .20a
6 months	9 months
21.3 \pm .11a	20.03 \pm .11b
Immediately following freezing, 1 day	12 months
19.33 \pm .18b	20.28 \pm .18a
Immediately following freezing, 1 day ^C	12 months ^C
19.33 \pm .19b	20.25 \pm .19a

ab Differences between means on the same line are significant ($P < .05$); Mean \pm S.E.

^CIncludes only -10°F initial storage temperature.

were signs that compared to patties initially stored at -10°F , 0°F initial storage produced more of an increase in fat content when compared to just post-freezing (Table 280). The percent fat in the cooked patties increased between nine and twelve months for patties from the 0°F in 96 hour rate, but not for the other rates (Table 281). All final temperature abuse combinations at twelve months showed an increase in cooked fat content, except for patties stored finally at -10°F and receiving temperature abuse (Table 282).

General expressible moisture values are given in Table 283. Values were inconsistent throughout the study. The 0°F in 48 hour rate formulation had more expressible moisture than the 0°F in 24 hour rate (Table 284), however, just post-freezing there were no rate effects. The 0°F in 48 hour frozen patties declined in expressible moisture as a result of freezing. After nine months, the 0°F in 72 hour rate had lower expressible moisture than the other rates, while this rate had more expressible moisture than the 0°F in 48 hour rate following twelve months storage (Table 285). After six months of storage, for temperature abused, $+20^{\circ}\text{F}$ stored product, the 0°F in 48 hour rate produced more expressible moisture than the 0°F in 96 hour rate (Table 286). Within nonabused $+20^{\circ}\text{F}$ stored product, the 0°F in 96 hour freezing rate produced more expressible moisture than the 0°F in 72 hour rate. There were indications at twelve months of more expressible moisture associated with 0°F rather than -10°F initial storage within the 0°F in 48 hour freezing rate (Table 287). At twelve months within the 0°F in 48 hour rate, patties (abused) that were finally stored at -10°F contained more expressible moisture than patties (nonabused) finally stored at 0°F (Table 288).

Table 280. Effect of storage time (immediately following freezing, nine months) on percent fat in cooked beef patties without soya^a

9 months storage				
Immediately following freezing, 1 day	Initial Storage temperature, °F =	-10		0
	Final Storage temperature, °F =	-10	0	-10
		19.94 ± .19	19.95 ± .19	20.11 ± .19
		19.33 ± .19		20.13 ± .19

^adifferences between times significant (P<.05) by analysis of variance, but not by HSD; Mean ± S.E.

Table 281. Interaction effect of storage time (nine, twelve months) and freezing rate on percent fat in cooked patties without soy

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
9	19.67 \pm .18b	20.15 \pm .18ab	20.53 \pm .18ab	19.78 \pm .18b
12	20.02 \pm .18ab	20.55 \pm .18ab	19.83 \pm .18b	20.73 \pm .18a

ab Any mean comparisons with the same letters are not different ($P > .05$);
Mean \pm S.E.

Table 282. Effect of storage time (immediately following freezing, twelve months) on percent fat in cooked beef patties without soy

12 months storage			
Immediately following freezing, 1 day	Temperature abuse		N
	Final Storage temperature, °F =	T	
	-10	0	-10
	20.45 ± .14a	20.11 ± .14a	19.87 ± .14ab
19.33 ± .14b			20.19 ± .14a

ab Means on the same line with the same letters are not different ($P > .05$); Mean ± S.E.;
T = temperature abused; N = Not temperature abused.

Table 283. General table illustrating the expressible moisture in raw ground beef patties without soy throughout storage times and according to final storage temperature and freezing rate - no statistical analyses^a

Evaluation time	Final storage temperature, °F	Freezing rate, hours to 0°F			
		24	48	72	96
Before freezing		.014 ± .0019	.017 ± .0011	.016 ± .0003	.015 ± .0013
Immediately after freezing, 1 day		.015 ± .0021	.014 ± .0013	.016 ± .0014	.014 ± .00093
6 months	-10 T	.013 ± .0019	.013 ± .001	.012 ± .0021	.012 ± .0012
	0 T	.014 ± .0022	.013 ± .0012	.012 ± .0018	.011 ± .0015
	20 T	.013 ± .0016	.015 ± .0013	.014 ± .0023	.012 ± .0020
	20 N	.013 ± .0012	.013 ± .0015	.012 ± .0014	.015 ± .0014
9 months	-10 T	.017 ± .0018	.015 ± .0023	.011 ± .0011	.015 ± .0014
	0 T	.015 ± .0013	.015 ± .0023	.013 ± .0015	.015 ± .0018
12 months	-10 T	.016 ± .0016	.016 ± .0027	.017 ± .0017	.015 ± .0021
	-10 N	.016 ± .0011	.014 ± .0014	.018 ± .0021	.017 ± .0013
	0 T	.016 ± .0024	.016 ± .0032	.016 ± .0021	.014 ± .0013
	0 N	.015 ± .0019	.012 ± .0014	.015 ± .0027	.016 ± .0017
18 months	-10 N	.013 ± .0029	.013 ± .0016	.014 ± .0017	.014 ± .0013
	0 N	.013 ± .0014	.013 ± .0015	--	--

^aMean ± S.D.; T = temperature abused; N = not temperature abused.

Table 284. Interaction effect of storage time (before freezing, immediately after freezing) and rate of freezing on expressible moisture in raw ground beef patties without soy

Evaluation Time	Freezing Rate, hours to 0°F			
	24	48	72	96
Before freezing	.014 ± .0004b	.017 ± .0004a	.016 ± .0004ab	.015 ± .0004ab
Immediately after freezing, 1 day	.015 ± .0004ab	.014 ± .0004b	.016 ± .0004ab	.014 ± .0004b

ab Any mean comparisons with the same letter are not different ($P>.05$); Mean ± S.E.



Table 285. Effect of freezing rate on expressible moisture in raw ground beef patties without soy following various storage periods

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
9	.016 \pm .0006a	.015 \pm .0006a	.012 \pm .0006b	.015 \pm .0006a
12	.016 \pm .00053ab	.014 \pm .00053b	.017 \pm .00053a	.015 \pm .00053ab

ab Means on the same line with the same letter are not different ($P > .05$); Mean \pm S.E.



Table 286. Interaction effect of final storage temperature and rate of freezing on expressible moisture in raw ground beef patties without soy following six months of storage

Final Storage Temperature, °F	Freezing Rate, hours to 0°F			
	24	48	72	96
-10 T	.013 \pm .00054abc	.013 \pm .00054abc	.012 \pm .00054c	.012 \pm .00054c
0 T	.014 \pm .00054abc	.013 \pm .00054abc	.012 \pm .00054bc	.011 \pm .00054c
20 T	.013 \pm .00054abc	.015 \pm .00054a	.014 \pm .00054abc	.012 \pm .00054bc
20 N	.013 \pm .00054abc	.013 \pm .00054abc	.012 \pm .00054c	.015 \pm .00054ab

abc Any mean comparison with the same letters are not different ($P > .05$); Mean \pm S.E.;
 T = temperature abused; N = not temperature abused.

Table 287. Interaction effect of initial storage temperature and rate of freezing on expressible moisture in raw ground beef patties without soy to following twelve months of storage^a

Initial Storage Temperature, °F	Freezing Rate, hours to 0°F			
	24	48	72	96
-10	.016 ± .00057	.014 ± .00057	.016 ± .00057	.015 ± .00057
0	.015 ± .00057	.016 ± .00057	.016 ± .00057	.015 ± .00057

^aInteraction significant ($P < .05$) by Analysis of Variance but not by HSD test.
Mean ± S.E.

Table 288. Interaction effect of final storage temperature and rate of freezing on expressible moisture in raw ground beef patties without soy following twelve months of storage

Final Storage Temperature, °F	Freezing Rate, hours to 0°F			
	24	48	72	96
-10 T	.016 \pm .00069ab	.016 \pm .00069a	.017 \pm .00069a	.015 \pm .00069ab
0 T	.016 \pm .00069ab	.016 \pm .00069ab	.016 \pm .00069a	.014 \pm .00069ab
0 N	.015 \pm .00069ab	.012 \pm .00069b	.015 \pm .00069ab	.016 \pm .00069ab

ab Any mean comparison with the same letters are not different ($P > .05$); Mean \pm S.E.;
T = temperature abused; N = not temperature abused.

At six months of storage, the only products to differ (lower) in expressible moisture from just post-freezing were patties from the 0°F in 72 hour rate initially and finally stored at -10°F and patties initially stored at 0°F, not abused and finally stored at +20°F (Table 289). Between six and nine months, expressible moisture went up for patties frozen to 0°F in 24 hours, and to 0°F in 96 hours (Table 290). Between nine and twelve months of storage, expressible moisture escalated for 0°F in 72 hour product (Table 291). No changes in expressible moisture were found between just after freezing and twelve months storage (Table 292). There were indications of a decline in expressible moisture between twelve and eighteen months for the 0°F in 24 hour rate, while the opposite was true for the 0°F in 48 hour rate (Table 293).



Table 289. Interaction effect of storage time (immediately following freezing, six months), initial storage temperature, final storage temperature and rate of freezing on expressible moisture of raw ground beef patties without soy

		Freezing rate, hours to 0°F			
		24	48	72	96
Immediately following freezing, 1 day		.015 ± .00075ab	.014 ± .00075ab	.016 ± .00075a	.014 ± .00075ab
6 months storage	Initial storage temp, °F				
	Final storage temp, °F				
	-10 T	.012 ± .00075b	.013 ± .00075ab	.011 ± .00075b	.011 ± .00075b
	0 T	.014 ± .00075ab	.013 ± .00075ab	.012 ± .00075ab	.012 ± .00075ab
	20 T	.013 ± .00075ab	.015 ± .00075ab	.013 ± .00075ab	.013 ± .00075ab
	20 N	.013 ± .00075ab	.013 ± .00075ab	.012 ± .00075ab	.015 ± .00075ab
	-10 T	.014 ± .00075ab	.014 ± .00075ab	.013 ± .00075ab	.012 ± .00075ab
	0 T	.014 ± .00075ab	.014 ± .00075ab	.012 ± .00075ab	.010 ± .00075b
0	20 T	.013 ± .00075ab	.016 ± .00075a	.015 ± .00075ab	.011 ± .00075b
	20 N	.014 ± .00075ab	.012 ± .00075ab	.011 ± .00075b	.015 ± .00075ab

ab Any mean comparisons with the same letter are not different ($P < .05$); Mean ± S.E.;
T = temperature abused; N = not temperature abused.



Table 290. Interaction effect of storage time (six, nine months) and rate of freezing on expressible moisture in raw ground beef patties without soy

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
6	.013 \pm .00039bc	.013 \pm .00039bc	.012 \pm .00039c	.011 \pm .00039c
9	.016 \pm .00039a	.015 \pm .00039ab	.012 \pm .00039c	.015 \pm .00039ab

abc Any mean comparisons with different letters are different ($P < .05$); Mean \pm S.E.



Table 291. Interaction effect of storage time (nine, twelve months) and rate of freezing on expressible moisture in raw ground beef patties without soy

Evaluation time, months	Freezing rate, hours to 0°F			
	24	48	72	96
9	.016 \pm .0004lab	.015 \pm .0004lab	.012 \pm .0004lc	.015 \pm .0004lab
12	.016 \pm .0004lab	.016 \pm .0004lab	.017 \pm .0004la	.014 \pm .0004lb

abc Any mean comparisons with the same letters are not different ($P > .05$); Mean \pm S.E.



Table 292. Interaction effect of storage time (immediately following freezing, twelve months) and rate of freezing on expressible moisture in raw ground beef patties without soy

		Freezing Rate, hours to 0°F			
		24	48	72	96
Immediately following freezing, 1 day		.015 + .00093ab	.014 + .00093ab	.016 + .00093ab	.014 + .00093ab
<u>12 Months Storage</u>					
Initial Storage Temperature, °F	Final Storage Temperature, °F				
-10	-10T	.016 + .00093ab	.016 + .00093ab	.017 + .00093a	.015 + .00093ab
	OT	.017 + .00093ab	.014 + .00093ab	.017 + .00093ab	.014 + .00093ab
	ON	.016 + .00093ab	.011 + .00093b	.015 + .00093ab	.015 + .00093ab
0	-10T	.016 + .00093ab	.017 + .00093ab	.017 + .00093ab	.015 + .00093ab
	OT	.015 + .00093ab	.018 + .00093a	.016 + .00093ab	.014 + .00093ab
	ON	.014 + .00093ab	.013 + .00093ab	.015 + .00093ab	.017 + .00093ab

ab Any mean comparison with the same letter is not different ($P > .05$); Mean + S.E.;
T = temperature abused; N = not temperature abused.



Table 293. Interaction effect of storage time and rate of freezing on expressible moisture in raw ground beef patties without soy^a

Evaluation time, months	Freezing rate, hours to 0°F	
	24	48
12	.015 \pm .00043	.012 \pm .00043
18	.013 \pm .00043	.013 \pm .00043

^aInteraction significant ($P < .05$) by Analysis of Variance but not by HSD test. Mean \pm S.E.



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